JUN 24 1925

ENGINEERING:

An Illustrated Weekly Journal.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

VOL. CXIX.—No. 3102.] *LONDON: FRIDAY, JUNE 12, 1925.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY INLAND POST 1s. 2½d.

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And Auxiliary Machinery as supplied to the Admiralty. 2179

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See Advertisement last week, page 13.

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See Advertisement, page 33, June 5.

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GLASGOW BIRMINGHAM LONDON.
See Advertisement, page 43. 2584

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PETERBOROUGH.
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REFRIGERATING PLANT. 2858
See Advertisement, page 51, June 5.

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See Full Page Advt., page 58, May 22.

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See Advert., page 95, May 22. 8195

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LIMITED.
See Advertisement page 60. 2402

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Draughtsmen, before Negotiating with Government Departments in connection with any post, please communicate with the GENERAL SECRETARY, Association of Engineering and Shipbuilding Draughtsmen, 96, St. George's Square, London, S.W.1. G 758

Engineering Salesmanship and SALES MANAGEMENT.—Write for brochure describing our special Course of Training for posts of unlimited scope in the lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 77, Milligate Building, Manchester. 2863

TENDERS.

THE DIRECTOR-GENERAL, INDIA STORE DEPARTMENT, Branch No. 16, Belvedere Road, Lambeth, S.E.1, invites

Tenders for :—

STEEL GIRDER BRIDGEWORK.
Tenders due on the 25th June, 1925.
Tender forms obtainable from above. J 297

BOMBAY, BARODA AND CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to 2.30 p.m. on Wednesday, 24th June,

Tenders for the Supply of :—

1. METALS.
2. STEEL MATERIAL (ANGLES, PLATES, ETC.).

Tenders must be made on forms, copies of which, with Specification, can be obtained at these Offices on payment of 10s. each (which will not be returned).
The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.

Offices: 91, Petty, France, Westminster, S.W.1.
8th June, 1925. J 298

GLOUCESTERSHIRE COUNTY COUNCIL.
LONDON—SOUTH WALES TRUNK ROAD A.40 IN GLOUCESTERSHIRE.
CONTRACTS.
THE HIGHWAYS AND GENERAL PURPOSES COMMITTEE OF THE GLOUCESTERSHIRE COUNTY COUNCIL invites

Tenders from Contractors for the following WORKS on the above-named Road :—

CONTRACT No. 4. The RECONSTRUCTION of the MAIN ROAD A.40 between GLOUCESTER and CHELTENHAM—approximate distance four and a half miles—in two coat asphalte work, with subsequent maintenance, also strengthening of haunches and subsidiary works.

Tenders for this Contract will only be considered from Firms of established reputation in asphalte construction and subsequent maintenance.

CONTRACT No. 7. The RECONSTRUCTION of the MAIN ROAD A.40 in the CHARLTON KINGS URBAN AREA between COPT ELM ROAD and HEARNE ROAD—approximate distance 620 yards—in Tarred asphaltic Macadam in two coats, with subsequent maintenance, with surface drainage, kerbing and other subsidiary works.

CONTRACT No. 8. The RECONSTRUCTION of the MAIN ROAD A.40 in the CHARLTON KINGS URBAN AREA from HEARNE ROAD to the BOUNDARY OF THE URBAN AREA AT DOWDESWELL—approximate distance 2140 yards—in two coats asphalte, with subsequent maintenance, also strengthening of haunches and other subsidiary works.

Tenders for this Contract will only be considered from Firms of established reputation in asphalte construction and subsequent maintenance.

Plans and detail drawings can be seen at the Office of the Resident Engineer, 10, Promenade, Cheltenham, and the General Conditions, Specification and Bills of Quantities can be obtained thereat on and after the 15th June, 1925, on payment of the sum of £5 5 0, which will be returned on the receipt of a *bona fide* Tender.

Tenders to be sent to the County Surveyor not later than the 1st July, 1925.

The COMMITTEE does not bind itself to accept the lowest or any other Tender.

COUNTY SURVEYOR,
Shire Hall, Gloucester.
6th June, 1925. J 249

COUNTY BOROUGH OF BRIGHTON.
WATERWORKS DEPARTMENT.

TO PIPE FOUNDERS.
The Waterworks Committee invite

Tenders for the Supply of about 360 tons of 16in. diameter Class "C," 240 tons of 18in. diameter Class "B," and about 320 tons of 18in. diameter Class "C" CAST IRON PIPES to the British Standard Specification, together with Specials of both diameters, delivered in Brighton.

Specification and Form of Tender may be obtained from the Waterworks Engineer, Mr. A. B. CATHCART, M.Inst.C.E., 12, Bond Street, Brighton, upon payment of a deposit of Two Guineas, which will be refunded upon receipt of a *bona fide* Tender not subsequently withdrawn.

Sealed Tenders, endorsed "Tender for C.I. Pipes," to be delivered at my Office, Town Hall, Brighton, not later than Noon, on Monday, July 6th, 1925.

The Committee do not bind themselves to accept the lowest or any Tender.

JAS. H. ROTHWELL,
Town Clerk.

Town Hall, Brighton,
10th June, 1925. J 307

THE BENGAL AND NORTH-WESTERN RAILWAY COMPANY LIMITED.

The Directors are prepared to receive

Tenders for the Supply of :—

310 Tons STEEL MATERIAL,
98 Tons WROUGHT IRON,

as per Specifications to be seen at the Company's Offices.

Tenders addressed to the undersigned, and marked "Tender for Steel Material," or as the case may be, with name of firm tendering to be lodged not later than Noon, on the 23rd day of June, 1925.

For each Specification a fee of 10/- will be charged, which cannot, under any circumstances, be returned.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
E. A. NEVILLE,
Managing Director.

237, Gresham House, Old Broad Street, London, E.C.2. 8th June, 1925. J 278

CITY OF LEICESTER.

STORM WATER AND SEWAGE DISPOSAL WORKS.

CONTRACT No. 3.
BACTERIAL WORKS, BEAUMONT LEYS FARM.
The Leicester Corporation are prepared to receive

Tenders for the Construction of New Sedimentation Tanks, Percolating Filters, Channels, Humus Tanks, Drains and Pipe Lines, Roads, and the erection of new Pumping Stations, Recorder House, etc., and all other Works in connection therewith, according to the drawings prepared by the City Surveyor.

Plans may be seen and copies of the Conditions of Contract, Specification, Bill of Quantities, with Form of Tender, etc., obtained at my Office on and after 15th June, 1925, on payment of the sum of £5, which will be returned on receipt of a *bona-fide* Tender.

Cheques, etc., to be crossed and made payable to the Leicester Corporation.

Fully priced Quantities, together with the Summary of Tender and Tender on the Forms supplied, filled up and addressed to "The Chairman of the Sewage Works and Farms Committee, Town Hall, Leicester," are to be delivered complete not later than Nine a.m. on 11th July, 1925, endorsed "Tender for Bacterial Works."

The Corporation do not bind themselves to accept the lowest or any Tender.

E. GEORGE MAWBEY, M.Inst.C.E.
City Engineer and Surveyor.

Town Hall, Leicester,
June, 1925. J 292

THE ASSAM-BENGAL RAILWAY COMPANY, LIMITED, is prepared to receive

Tenders for :—

STEEL TYRES for Carriages and Wagons,

Specifications and Tender Forms may be obtained at the Offices of the Company, Bishopsgate House, 80, Bishopsgate, E.C.2. A fee of £1 1s. is charged, which cannot under any circumstances be returned.

Drawings may be had at the cost of the Tenderer, by application to Messrs. HODGES, BENNETT & Co., LTD., 78 Queen Victoria Street, E.C.4.

Tenders must be delivered at the Company's Offices not later than Noon, on Wednesday, the 24th June, 1925.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
OSWALD I. MILNE, Secretary.
8th June, 1925. J 281

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for the Supply of :—

1. R.S. DISC WHEELS and AXLES.
2. SOLID DRAWN STEEL BOILER TUBES (3).
3. STEEL FISHPLATES.
4. TIE BARS, GIBS and COTTERS.
5. CAST IRON POT SLEEPERS.
6. FISHBOLTS, NUTS and WASHERS.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tender for Wheels and Axles," or as the case may be, must be left with the undersigned not later than Twelve Noon, on Friday, the 26th June, 1925.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 10s. for each copy of Specifications Nos. 1, 2, 3 and 4, of £1 for each copy of Specification No. 5, and of 5s. for each copy of Specification No. 6.

Copies of the Drawings may be obtained at the Offices of the Company's Consulting Engineers, Messrs. ROBERT WHITE & PARTNERS, of 3, Victoria Street, Westminster, S.W.1.

A. MUIRHEAD,
Managing Director.

91, Petty France, Westminster, S.W.1.
9th June, 1925. J 299

CITY AND COUNTY OF NORWICH.
THORPE POWER STATION.

The Norwich Corporation invite

Tenders for the Manufacture, DELIVERY and ERECTION of the undermentioned ENGINEERING WORKS in connection with the above Power Station, viz. :—

STEAM, WATER and other PIPEWORK, VALVES, TANKS, etc., etc.

Specifications, Drawings and Forms of Tender may be obtained from Messrs. PREECE, CARDEW AND RIDER, 8, Queen Anne's Gate, Westminster, S.W.1, on payment of a deposit of £5, which will be refunded on receipt of a *bona fide* Tender within the prescribed time.

Two Copies of the Specification and Form of Tender will be supplied to each applicant. Extra copies may be obtained on payment of Ten Shillings for each copy, which will not be returnable.

Sealed Tenders, endorsed "Thorpe Power Station, Tender for Pipework, etc.," must be delivered to me at my Office not later than Ten a.m. on Friday, 3rd July, 1925.

The lowest or any Tender will not necessarily be accepted and the Corporation will not consider any Tender which is incomplete, or which does not include the whole of the work covered by the Specification.

ARNOLD H. MILLER,
Town Clerk.

Guildhall, Norwich.
8th June, 1925. J 268

COUNTY BOROUGH OF BRIGHTON.
WATERWORKS DEPARTMENT.

TO MAINLAYING CONTRACTORS.
The Waterworks Committee are prepared to receive

Tenders from responsible Contractors for LAYING about 2520 yards of 18in., and about 1780 yards of 16in. CAST IRON MAINS in Ditchling Road, Hollingbury Road, Hollingdean Road, Old Lane, and Surrenden Road, Brighton.

Specification, Quantities, and Form of Tender may be obtained, and Drawings inspected, on application to Mr. A. B. CATHCART, M.Inst.C.E., Waterworks Engineer, 12, Bond Street, Brighton, on payment of a deposit of Three Guineas, which will be refunded upon receipt of a *bona fide* Tender, not subsequently withdrawn, and the return of all documents.

Sealed Tenders, endorsed "Tender for laying 18in. and 16in. Water Mains," to be delivered at my Office, Town Hall, Brighton, not later than Noon, on Monday, July 6th, 1925.

The lowest or any Tender will not necessarily be accepted, and Tenders will only be considered from responsible Contractors having the necessary experience.

JAS. H. ROTHWELL,
Town Clerk.

Town Hall, Brighton.
10th June, 1925. J 308

METROPOLITAN WATER BOARD.

HONOR OAK RESERVOIR SUPPLY MAINS.
TENDER FOR THE LAYING AND JOINTING of 42 in., 27 in. and 15 in. diameter CAST IRON MAINS, from Homestall Road, Camberwell, to Queen's Road, Peckham.

The Metropolitan Water Board invite

Tenders for the Laying of 42 in., 27 in. and 15 in. internal diameter WATER MAINS, from Homestall Road, Camberwell, to Queen's Road, Peckham, together with contingent works.

Drawings, Conditions of Contract and Specification may be inspected without payment of a fee, at the Offices of the Board, Chief Engineer's Department (Room 201), on and after 16th June.

Form of Tender, Conditions of Contract and Specification, Bills of Quantities, Schedules of prices, together with drawings and a spare copy of the Bills of Quantities and Schedules of Prices may be obtained on and after 16th of June from Mr. HENRY E. STILGOE, M.Inst.C.E., the Chief Engineer, on the production of an official receipt for the sum of £10, which sum must be deposited with the Accountant to the Board, at 173, Rosebery Avenue, Clerkenwell, E.C.1. and will be returned on receipt of a *bona fide* Tender, accompanied by all the above-named documents and drawings (with the exception of the spare copy of the Bills of Quantities and Schedules of Prices, which may be retained by the Tenderer).

Such payments and applications must be made between the hours of Ten a.m. and 4.30 p.m. (Saturdays, Ten a.m. and Twelve Noon).

Cheques must be made payable to "The Metropolitan Water Board" and not to individuals.

Tenders enclosed in sealed envelopes, addressed to "The Clerk of the Board, Metropolitan Water Board, 173, Rosebery Avenue, Clerkenwell, E.C.1." and endorsed "Tender for Honor Oak Reservoir Supply Mains," must be delivered at the offices of the Board not later than Ten a.m., on Tuesday, 7th July, 1925.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER,
Clerk of the Board.

Offices of the Board,
173, Rosebery Avenue,
Clerkenwell, E.C.1. J 313

APPOINTMENTS OPEN.

SWINDON AND NORTH WILTS TECHNICAL INSTITUTION.

Applications are Invited for the POST of HEAD OF THE ENGINEERING DEPARTMENT from graduates with both Teaching and Works experience.

Salary in accordance with Burnham Agreements, as approved by the Board of Education, including an addition of £50 for Special Responsibility.

Further particulars and forms of application may be obtained from the PRINCIPAL, TECHNICAL INSTITUTION, SWINDON, not later than Wednesday, 24th June, 1925.

W. SEATON,
Secretary.
J 286

The Trustees of the Port and HARBOURS of GREENOCK REQUIRE the advisory services of a CONSULTING ENGINEER with large experience in Dock, Graving Dock Mechanical Reinforced Concrete, Steelwork, etc.—Apply, giving full particulars, experience and retaining fee required, to J. MCLELLAN, Clerk to the Trustees. Envelope to be marked, "Consulting Engineer." J 315

STOCKPORT TECHNICAL SCHOOL.
Principal: J. F. S. ROSS, M.C., B.Sc., Assoc.M.Inst.C.E.

DEPARTMENT OF ENGINEERING.

Applications are Invited for the Full-time POST of LECTURER IN ENGINEERING. Candidates should possess a University degree, or equivalent qualification, in Mechanical Engineering, together with both works and teaching experience. Preference will be given to candidates having a knowledge of either Civil or Electrical Engineering in addition to Mechanical.

Salary in accordance with the Burnham Award. Duties to commence on 1st September, 1925.

Form of application and further particulars may be obtained by sending stamped addressed foolscap envelope to the Principal, to whom applications must be sent not later than Wednesday, 24th June, 1925.

ARTHUR LAWTON, M.A.,
Secretary of Education. J 267

CAPE TECHNICAL COLLEGE, CAPE TOWN.

Applications are Invited for an ENGINEERING LECTURER. Graduate (or equivalent) in electrical engineering who has had a workshop training and subsequent experience in one or more of the branches of light-current engineering. The lecturer will be expected to conduct classes in telegraphy and telephony, wireless telegraphy and telephony and physics, and assist in the light-current section of the Department of Electrical Engineering.

Applications, in duplicate, must be submitted with certified copies of testimonials giving evidence of workshop experience, other experience, technical qualifications and stating age of candidate before 23rd June, 1925. Salary £400-25-£500.

Conditions of service and other particulars may be had on application to :—

Messrs. CHALMERS, GUTHRIE & CO., LTD.,
9, Idol Lane,
London, E.C.3. J 223

MUNICIPAL TECHNICAL COLLEGE, SWANSEA.

Principal—T. GILBERT JONES, M.Sc., Wh.Sch., A.M.I.E.E., A.M.I.C.E.

LECTURESHIP IN ELECTRICAL ENGINEERING.

Applications are Invited for the POSITION of LECTURER in Electrical Engineering. Applicants must possess a University degree or its equivalent and have had works experience. Teaching experience desirable. Salary according to Burnham Technical Scale. Forms of application and conditions of appointment may be obtained from the undersigned, by whom applications, accompanied by copies of recent testimonials, must be received not later than first post on WEDNESDAY, the 24th June.

T. J. REES,
Director of Education.

Education Office,
Dynevor Place, SWANSEA.
9th June, 1925. J 289

WARWICKSHIRE COUNTY COUNCIL.

TEMPORARY ENGINEERING ASSISTANT.

Applications are Invited for the above APPOINTMENT, at a salary at the rate of £400 per annum.

Candidates must have a thorough knowledge of the design and construction of reinforced concrete work, including bridges.

The Appointment will probably be for a period of at least 12 months.

Applications, stating age, qualifications and when able to commence duties, together with copies of two recent testimonials, must be delivered to the undersigned as soon as possible, but not later than the 22nd instant.

D. H. BROWN,
County Surveyor.

County Surveyor's Office,
8, Northgate Street,
Warwick.
10th June, 1925. J 306

ADMINISTRATIVE COUNTY OF LONDON.

The London County Council will

Require, in September next, at the L.C.C. School of Engineering and Navigation, High Street, Poplar, an ASSISTANT WHOLE-TIME INSTRUCTOR of Marine Engineering.

Candidates must possess extra first-class engineer's Board of Trade Certificate. Teaching experience desirable.

Salary in accordance with a scale to be formulated by the Council in the light of the new "Burnham" award. The scale for instructors has hitherto been £300, rising by annual increments of £15 to £425, subject to an abatement of five per cent. Commencing salary according to experience.

Preference given to those who served or attempted to serve with H.M. Forces. Apply to the Education Officer (T.I.A.), The County Hall, Westminster Bridge, S.E.1 (Stamped addressed foolscap envelope necessary), for form, to be returned by 20th June, 1925. Canvassing disqualifies.

MONTAGU H. COX,
Clerk of the London County Council. J 304

Civil Engineers (Two) REQUIRED by the GOVERNMENT of the GOLD COAST for the PUBLIC WORKS DEPARTMENT for a tour of from 12 to 18 months' service. Free passages and quarters and liberal leave on full salary. Outfit allowance of £60 on first appointment. Salary, £480 for the first three years of service, and then £510, rising to £730 by annual increments of £30, and thence rising to £930 by annual increments of £40. Candidates, aged 28-35, preferably Associate Members of the Institute of Civil Engineers, should be good surveyors and have had considerable experience in practical town planning and be conversant with Ministry of Health procedure on town planning.—Apply at once, by letter, stating age, qualifications and experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W.1, quoting M/13510. J 309

A RATIONAL PILE-DRIVING FORMULA AND ITS APPLICATION IN PILING PRACTICE EXPLAINED.

By A. HILEY, M.I.N.A., Assoc.M.Inst.C.E.

(*Concluded from page* 658.)

Temporary Compression per Blow.—The amount of temporary elastic compression is an important factor in the determination of the work done on the pile, and its amount can be calculated with reference to the stress transmitted, the length of pile and the character of pile cap. The compression c consists in two parts, one called C_1 being the general shortening of the pile under stress, and the other, C_2, being the local effects of a higher stress obtaining in the head of the pile and cap. The amount of C_1 can be estimated from the particulars of the pile, and can be also measured by the use of a pile set-gauge comprising a linen tape measure pulled frictionally through an independently-supported clamp, in which inertia of the recording features is eliminated; but as such recorded strain may also include a proportion occasioned by the inertia stress set up in the upper part of the pile, it is preferable to calculate the allowances for the temporary compressive strain with reference only to the force R, the value of Young's modulus, and length of pile, as the additional local strain is already taken into account in our use of the efficiency η_b of the blow, as defined. The temporary compression in the case of straight piles driven into the ground is assumed to take place over a length of pile equal to the measured full length, using the figures for compression given in Table III expressed in inches.

The amount to allow for the temporary compression (C_1) of pile for the different driving pressures stated is given in the following table :—

TABLE III.

Type of Pile.	Temporary Compression for 10-ft. Length of Pile as Reckoned.			
	p=500lb./sq. in. Easy Driving.	p=1,000 lb./sq. in. Medium Driving.	p=1,500 lb./sq. in. Hard Driving.	p=2,000 lb./sq. in. Very Hard Driving.
(1) Timber pile ..	0·04	0·07	0·11	0·15
(2) R.C. pile ..	0·03	0·05	0·08	0·11
(4) Steel tubular Vibro pile	0·02	0·03	0·05	0·07
(5) Steel sheet pile	0·01	0·02	0·03	0·04

In the above table C_1 has been calculated from $\frac{\text{stress} \times \text{length}}{E}$, using for Young's modulus in case of (1) timber piles E = 1,750,000; (2) R.C. piles, E = 2,500,000; (4) Vibro pile tubes, E = 30 × 10^6 and multiply by the ratio of

$$\frac{A_0}{A} = \frac{240 \text{ sq. in.}}{36 \text{ sq. in.}}$$

And for (5) steel sheet piles, for which E = 30 × 10^6, a further allowance has been made to take account of the probable off-centred blow and lateral deflection.

When the pile is fitted with a helmet or driving cap a certain additional wastage of energy takes place, and this is allowed for by adding a nominal compressive strain C_2 corresponding to a stress p transmitted as given in the Table IV.

TABLE IV.

Temporary Strain Allowance C_2 for Pile Cap when Employed.

—	p=500 lb/sq. in.	p=1,000 lb./sq. in.	p=1,500 lb./sq. in.	p=2,000 lb./sq. in.
Helmet and dolley for R.C. piles	0·05	0·10	0·15	0·20
Steel-covered cap for Vibro-pile tubes	0·04	0·08	0·12	0·15

In the above table of allowances for C_2 the arrangement of the helmet packing and short dolly has been considered for the minimum extent of compression likely to occur with these items in very good condition. If the dolly be moderately long the allowance for C_2 should be increased by half as much again, and in cases where the packing in the helmet is unduly compressible the allowance for C_2 will probably be double of the minimum stated, as given in inches.

The steel-covered cap used in driving Vibro piling tubes is of standardised design, and its behaviour under the hammer blows is not liable to any appreciable variation from the figures given.

The total allowance for temporary compression c to include in the calculation of driving resistance is summarised in Table V for different lengths of piles.

For any intermediate stress p corresponding to a stipulated resistance to be overcome, for which the resulting set per blow has to be found, the value of c can be got by interpolation, as it varies directly as the stress p and with the length of pile.

The foregoing data now at our disposal can be utilised to illustrate in diagrammatic form the relationship between the height of fall of a hammer of a given weight which is necessary to overtake any desired amount of ground resistance, and also to indicate the necessary height of fall to produce any specified set or penetration of the pile into the ground per blow.

Fig. 2 shows the relation between the height of

TABLE V.

Length of Pile in Feet.	Total Allowance for Temporary Compression C in Inches per Blow.															
	For p = 500 Lbs./Sq. Inch.				For p = 1,000 Lbs./Sq. Inch.				For p = 1,500 Lbs./Sq. Inch.				For p = 2,000 Lbs./Sq. Inch.			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
10	0·04	0·03	0·08	0·06	0·07	0·05	0·15	0·11	0·11	0·08	0·23	0·17	0·15	0·11	0·31	0·22
15	0·06	0·05	0·10	0·07	0·11	0·08	0·18	0·12	0·17	0·12	0·28	0·19	0·22	0·16	0·36	0·25
20	0·08	0·06	0·11	0·08	0·14	0·10	0·20	0·14	0·22	0·16	0·31	0·22	0·30	0·22	0·42	0·29
25	0·10	0·08	0·13	0·09	0·18	0·13	0·23	0·15	0·28	0·20	0·35	0·24	0·38	0·28	0·48	0·32
30	0·12	0·09	0·14	0·10	0·21	0·15	0·25	0·17	0·33	0·24	0·39	0·27	0·45	0·33	0·53	0·36
35	0·14	0·11	0·16	0·11	0·25	0·17	0·27	0·18	0·39	0·28	0·43	0·29	0·52	0·39	0·59	0·39
40	0·16	0·12	0·17	0·12	0·28	0·20	0·30	0·19	0·44	0·32	0·47	0·32	0·60	0·44	0·64	0·43
45	0·18	0·14	0·19	0·13	0·32	0·22	0·32	0·21	0·50	0·36	0·51	0·34	0·67	0·50	0·70	0·46
50	0·20	0·15	0·20	0·14	0·35	0·25	0·35	0·23	0·55	0·40	0·55	0·37	0·75	0·55	0·75	0·51
55	0·22	0·17	0·22	0·15	0·39	0·27	0·37	0·24	0·61	0·44	0·59	0·39	0·82	0·61	0·81	0·53
60	0·24	0·18	0·23	0·16	0·42	0·30	0·40	0·26	0·66	0·48	0·63	0·42	0·90	0·66	0·86	0·57
65	0·26	0·20	0·25	0·17	0·46	0·32	0·42	0·27	0·72	0·52	0·67	0·44	0·98	0·72	0·92	0·64
70	0·28	0·21	0·26	0·18	0·49	0·35	0·45	0·29	0·77	0·56	0·71	0·47	1·05	0·77	0·97	0·64
75	0·30	0·23	0·28	0·19	0·53	0·38	0·48	0·30	0·83	0·60	0·75	0·49	1·13	0·83	1·03	0·67
80	0·32	0·24	0·29	0·20	0·56	0·40	0·50	0·32	0·88	0·64	0·79	0·52	1·20	0·88	1·08	0·71
90	0·36	0·27	0·32	0·22	0·63	0·45	0·55	0·35	0·99	0·72	0·87	0·57	1·35	1·00	1·20	0·78
100	0·40	0·30	0·35	0·24	0·70	0·50	0·60	0·38	1·10	0·80	0·95	0·62	1·50	1·10	1·30	0·85

Column (1) is for parallel sided timber piles, blow direct on pile head.
(2) ,, ,, reinforced concrete piles direct on pile head.
(3) ,, ,, ,, ,, ,, blow on dolly and helmet.
(4) ,, Vibro steel pile tube, blow on metal covered cap.
p = stress transmitted in lbs. per square inch on cross section of pile, when overcoming the ground resistance R.

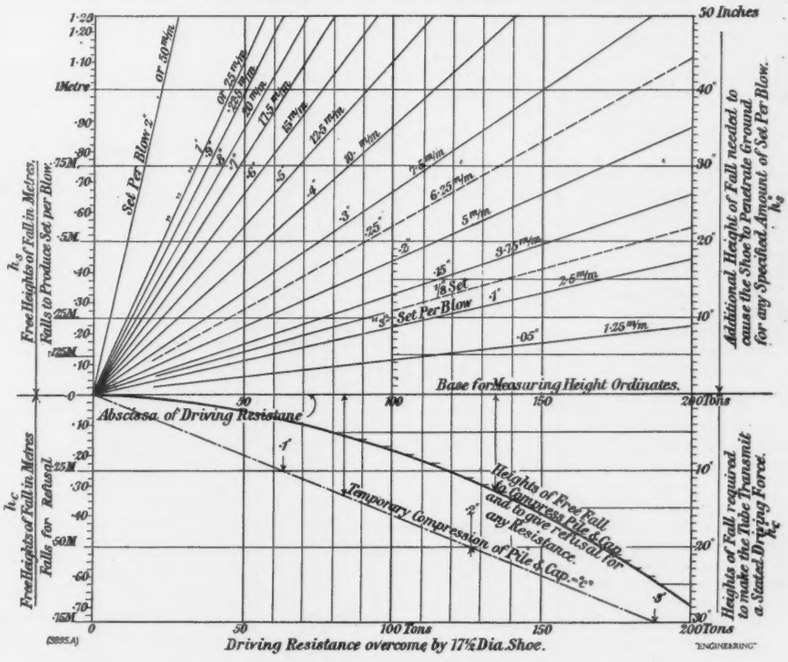

50 Inches
Set Per Blow 2" or 50 m/m.
Free Heights of Fall in Metres. Falls to Produce Set per Blow.
Additional Height of Fall needed to cause the Shoe to Penetrate Ground for any Specified Amount of Set Per Blow.
Base for Measuring Height Ordinates.
Abscissa of Driving Resistance
Temporary Compression of Pile & Cap.=2"
Heights of Free Fall to Compress Pile & Cap and give Refusal for any Resistance.
Heights of Fall required to make the Tube Transmit a Stated Driving Force.
100 Tons
200 Tons
Driving Resistance overcome by 17½ Dia. Shoe.
"ENGINEERING"

FIG. 2. VIBRO CONCRETE PILING.

No. 1 diagram showing height of fall of 2-ton S.A. Vibro hammer to suit any specified set per blow, and give the required driving force.

This diagram applies to a tube of length = 22 ft. 6 in. and fitted with metal-covered cap.

P = weight of pile-tube and cap and shoe. W = weight of ram of hammer. η_b efficiency of the blow. R = resistance. s = set per blow. c = temporary compression of pile.

$$\frac{P}{W} = \frac{1{\cdot}85 \text{ tons}}{2 \text{ tons}} = 0{\cdot}92 \text{ ratio.} \qquad \eta_b = \frac{W + 0{\cdot}1\,P}{W + P} = 57 \text{ per cent.} \qquad h'' = \frac{R \times \frac{c}{2}}{W \times \eta_b} \div \frac{R \times s}{W \times \eta_b} = h_c \div h_s.$$

h'' = free fall of ram.

The actual height of fall, H, is obtained for S.A. hammers by adding to h'', 4 per cent. to allow for friction and 2 in. to allow for valve opening to its exhaust position. This allowance averages from 2 in. to 4 in. extra, or from 5 cm. to 10 cm. extra.

fall and the set produced, portrayed by the curves, one of which reveals the effect of the elasticity of the pile dealt with, and the remainder indicate the magnitude of the set which will correspond with any particular height of fall given by the hammer beyond that which would meet with refusal in respect to any definite resistance met with in the strata penetrated by the pile-shoe.

A series of curves similar to No. 1 diagram are likewise prepared for each increased length of pile tube employed up to 60 ft., and to facilitate their use in the field these are simplified to show the actual height of fall scaled from a horizontal base of resistance expressed in tons.

The sets shown by such curves, selecting definite heights of fall and contending with a resistance as found, are in agreement with recorded measurements taken for varying heights of fall given by the hammer, starting from the height for refusal and extending by increments of 6 in. to the full stroke, amounting to 4 ft. 6 in.

The use of curves such as described provides a convenient means for setting out the essential information when dealing with piles all of the same size, more especially where the piling plant is of standardised type throughout.

In general instances of ordinary pile driving, the information sought, relating to a given case, can be readily supplied by applying the formula (1) to the problem direct, and using the necessary data which would be available for the purpose.

Table VI, annexed, summarises the results obtained by applying formulæ (1) and (3) in the case of several types of piles, and shows the relationship existing between the driving resistance, the set per blow and the height of fall to give refusal.

The driving stress f_c in the material of pile near the head can be approximately estimated as

$$f_c = \frac{W \cdot h}{s + c} \times \frac{2240}{\text{area}},$$

and for timber piles this should not exceed one-third of crushing strength. For R.C. piles driven direct, preferably by a heavy ram and short fall, this should be restricted to one-half of the crushing strength of concrete, and if fitted with helmets to two-thirds of the crushing strength of concrete. For Vibro concrete piles a driving resistance of 150 tons can safely be negotiated over prolonged periods without affecting the drive cap.

Investigations into the relationship between the amount of direct support a pile receives below the shoe, and that afforded by the frictional resistance against the side area indicates that for ground conditions where the strata is of the same nature throughout the depth with no abrupt final increase in density, the ratio between the two can be expressed as $d^2 : \frac{d \cdot l}{40}$, and this applies to general cases, where the driving at half the total depth has been found, from a reference to the set per blow and the properly-computed resistance, to be about one-third of the final resistance.

If the pile is found to have passed through moist ground of a lesser resistance at mid-depth and to get into a much denser strata at the finish, then the ratio of the direct to the frictional resistance components would approach $d^2 : \frac{d \cdot l}{80}$

where

d = the diameter or side dimensions of pile in feet.
l = the length of the pile below ground in feet.

In the cases of timber and pre-cast piles the driving resistance R already includes the friction along the sides and in the examples given the 120 tons stated value of R represents the full amount available for coping with the working load.

In the case of the Vibro concrete pile, on the other hand, the driving resistance R is to all intents and purposes confined to the direct resistance occurring below the pile shoe, which is of larger diameter than the tube which follows. The concrete pile being cast and rammed into the ground only during the withdrawal of the driving tube which the finished pile replaces, the frictional element of the resistance is acquired as a resistance additional to the driving resistance of amount R.

Taking, again, the 120 tons as the resistance overcome in driving the shoe, then the total resistance including for friction and assuming a uniform nature of ground, would amount to

$$R \times \frac{d^2 + \frac{d \cdot l}{40}}{d^2} = 120 \text{ tons} \times \frac{2 \cdot 15 + 1 \cdot 46}{2 \cdot 15} = 200 \text{ tons}$$

A pile thus driven and afterwards cast *in situ* becomes for the same limit of driving, capable of taking over 50 per cent. greater load as obtains in the case of ordinary direct-driven piles of substantially the same area and strength.

If the density of the upper strata had been of the lesser order of supporting value the total resistance would of an intermediate amount as

$$R \times \frac{d^2 + \frac{d \cdot l}{80}}{d^2} = 120 \text{ tons} \times \frac{2 \cdot 15 + 0 \cdot 73}{2 \cdot 15} = 160 \text{ tons}$$

which, nevertheless, still provides an appreciable increment above the common driving resistance of 120 tons.

Should it be required to furnish the total resistance as 120 tons or thereabouts, the same as for the directly driven piles, the resistance which should be reached in driving the shoe would be

$$R = 120 \text{ tons} \times \frac{2 \cdot 15}{2 \cdot 15 + 0 \cdot 65} = 92 \text{ tons}$$

or, say, arrange the driving resistance to be 100 tons, which should ordinarily be expected to occur at a depth of 35 ft. if the 120 tons occurred at 40 ft., and in this event an appreciable saving in cost of the pile would be secured whilst providing the same figure, 120 tons ultimate bearing capacity in place of 160 tons.

For the purpose of forming an idea of the depth to which it will probably be necessary to drive piles to furnish the resistance desired. The probable direct resistance r_s per square foot, at a depth h ft., which can be developed below the projected area of pile shoe may be approximated by the formula

$$h \times w \left(\frac{1 + \sin \phi}{1 - \sin \phi}\right)^2 = r_s$$

Where, for instance, the shoe is found to penetrate into a gravel strata, the value of ϕ, which takes account of the resistance to displacement of the particles of earth, might be selected as 40 deg. to 50 deg.; and the value w, which is an index to the density of the material and the possibility which exists for further compacting the same in lessening the percentage of voids within it, may be chosen as 120 to 130 lb. per cubic feet. Conversally, if the resistance at any given depth has been ascertained from records taken when driving a pile, the values of ϕ and w can be computed to suit, from which particulars the frictional value of the strata passed through can be directly estimated.

The above approximation to the ground resistance r_s is servicable enough for ordinary cases; but, actually, some further considerations can usefully be taken into account. These relate to the frictional condition of dry, moist and lubricated kinds of earth, and also the wedge effect of different forms of pointed piles or shoes which may be employed, but it is considered unnecessary to elaborate on these influences for any benefit it would serve in the present review.

The amount of penetration effected per blow when driving a pile requires also to be considered in relation to the time involved in doing the work of driving the full length. To secure economical results, the hammer would generally be considered suitable, if it is capable of driving at full penetration with a speed of 3 inches per minute, and at half the full penetration at a rate of about 3 ft. per minute.

Broadly speaking, a drop-hammer worked from a winch will give about 20 blows per minute; single-acting steam hammers which are raised by steam and allowed to fall by gravity, give out 40 blows per minute. Double-acting automatic steam hammers give out a large number of blows ranging from 250 in medium sizes to 120 per minute in the largest size; and for hammers of this class the set per blow can be permitted to be less than what would be required to be furnished by hammers which have almost their whole weight devoted to the ram and work at a slower rate.

To preserve the conditions favourable to steady driving involves care being also taken to keep the driving stresses from exceeding a safe strut-value of the pile. This can be ascertained for the length above ground after assuming the upper end steadied in position, and fixed in position and direction at ground level.

Factor of Safety.—The factor of safety which can be used in any particular case to arrive at the safe carrying capacity in relation to the driving resistance R may, in general, lie between 3 to 4 to be in harmony with that obtaining in the superstructure. Test loads of 50 per cent. more than the working load should then be unable to produce any settlement.

TABLE VI.

Type of Pile.	Size.	Length	Weight of Pile P	Type of Hammer.	Weight of Ram W	$\frac{P}{W}$	η_b	h' Equivalent Free Fall.	Driving Resist'. R Stipulated.	Driving Stress p.	Compression c.	Set per Blow.	Actual Height of Fall of Ram	Actual Fall at Refusal.
	Inches	Feet.	Tons.	Steam	Tons.			Inches.	Tons.	Lb./Sq.″	Inches.	Inches.	Inches.	Inches.
Timber pile ..	14 × 14	40	1·0	S.A.	2	0·5	0·68	50	120	1,360	0·40	0·37	54	21
R.C. pile direct drive	14 × 14	40	3·65	S.A.	2	1·8	0·46	20	88	1,000	0·20	0·11	24	12
R.C. pile with helmet & dolly	14 × 14	40	4·0	S.A.	2	2·0	0·38	42	120	1,360	0·43	0·05	46	37
Vibro concrete steel pile tube and 17½″ dia. shoe	(Tube) 16 × ⅜	40	2·75	S.A.	2	1·4	0·48	30	120	1,100	0·21	0·14	34	16

As affecting a considerable bulk of work dependent on efficient piling for support, shortcomings which if allowed to originate through the technical conditions not having been properly realised would, in the nature of this class of work, be very difficult to rectify. Instances have frequently recurred where the bearing capacity has, due to an unwarranted belief in exaggerated factors of safety attending the employment of mediocre formulæ, proved insufficient in practice and thereupon given rise to serious consequences. At other times an injudicious choice in size of hammer, or the use of an unsuitable height of fall, may on the one hand involve much fruitless effort if the hammer be too light, and on the other, might result in material damage to the pile itself.

As any of such errors inevitably spell loss in one form or another, the writer has endeavoured to put into convenient form for every day requirements and use, a more technically correct method of treating the problem and one which can be followed with real advantage. The expectation may, it is hoped, be entertained that a considerable stride will be effected in this phase of civil engineering, with the wider adoption in practice of appropriate methods and scientific control, to place it on a par with contemporary engineering standards.

The author's acknowledgments are due to the Directors of the British Steel Piling Company for providing many facilities for establishing the satisfactory relationship between theory and practice in several extensive piling operations performed by their hammers on every variety of duty. The author's thanks are also extended to Mr. Ewart S. Andrews, B.Sc., for kindly placing valuable information in his hands for reference on this subject.

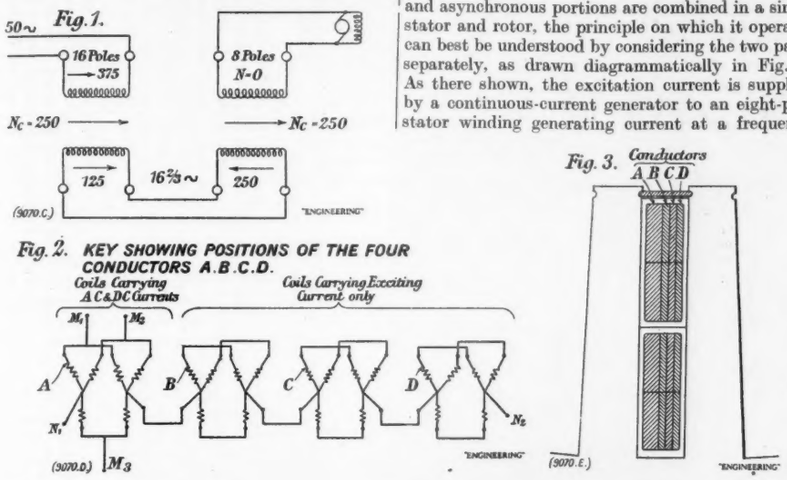
THE HUNT SELF-PARALLELING ALTERNATOR.

IT is a well-known fact that an ordinary polyphase induction motor, if driven at a speed exceeding that of synchronism, will act as a generator, returning energy to the line from which it would be supplied when running as a motor. An interesting property of the induction generator is that it requires no synchronising, the frequency of the output being always equal to that of the line, quite independently of the speed of rotation so long as this exceeds the synchronous speed. The drawback of such machines, however, is that they are not self-exciting, the excitation current having to be supplied from the line. Moreover, the excitation current is comparatively large, amounting to something of the order of 30 per cent. of the full-load output of the machine as a generator. An induction generator of the ordinary type can therefore only be used in parallel with synchronous generators which supply the magnetising current, and, for this reason, but few practical applications have been found for machines of the former type.

Recently, however, a new type of induction generator, possessing the advantages of that type of machine without its inherent drawbacks, has been developed by Mr. L. J. Hunt, M.Inst.C.E., M.I.E.E., 4, Broad-street Place, E.C. 2, whose well-known cascade induction motor we described in our issue of August 4, 1911, on page 173. The Hunt induction generator is, in effect, a combination of an induction and synchronous generator in a single machine, and the result is an alternator which does not require to be synchronised before connecting in parallel with other machines, and will therefore run satisfactorily in parallel under conditions which would render parallel running of ordinary alternators quite impossible.

Although in the actual machine the synchronous and asynchronous portions are combined in a single stator and rotor, the principle on which it operates can best be understood by considering the two parts separately, as drawn diagrammatically in Fig. 1. As there shown, the excitation current is supplied by a continuous-current generator to an eight-pole stator winding generating current at a frequency of 16 cycles per second in a rotor driven at 250 r.p.m. This current, supplied to a 16-pole rotor winding of a separate machine, would produce a field rotating at 125 r.p.m., even if the rotor itself were stationary. If, however, the rotors of the two machines are mechanically coupled so that both rotate at the same speed, *i.e.*, 250 r.p.m., a field rotating in space at 375 r.p.m. can be produced by the rotor of the second machine. Under these conditions, if the stator of the latter is provided with a 16-pole winding, alternating currents with a frequency of 50 cycles per second will be generated in that winding, and these currents can be tapped off to supply the line.

In practice, instead of employing separate mechanically-coupled machines, the generator has a single stator core provided with windings giving the resultant of the 16-pole and 8-pole fields. The construction adopted is similar to that of an induction motor, the stator and rotor cores being built up of laminations provided with slots for the windings, the slots of the stator being open and those of the rotor almost closed. In the rotor slots is a simple short-circuited winding producing the same effect as two independent 16-pole and 8-pole windings. The rotor of the particular machine to which we wish now to refer has 192 slots, in 96 of which there are two bars each, while in the remainder only one bar is required. In the stator there are 144 slots, in which are placed the windings shown diagrammatically in Fig. 2. In this figure, N_1 and N_2 indicate the connections through which the continuous exciting current is supplied, and M_1, M_2, and M_3 are the points at which the alternating current (three-phase) is tapped off. It will be seen that the latter is supplied by two sections of the winding connected to form two parallel stars. The exciting current flows through this winding, entering at the neutral point of one star and leaving from the neutral of the other. In each pair of parallel branches of the winding, the exciting current flows in the same direction as the alternating current in one star and in the opposite direction in the other star, the effect of the exciting current being to produce only eight poles, while the alternating current produces 16. The remainder of the winding carries the exciting current only, all the units of the winding being connected in series with the exciter. By arranging the windings in four similar units and placing similarly-situated wires of each unit in the same slot, as indicated in Figs. 2 and 3, the insulation required can be reduced to a minimum, since there is no difference of potential between them—a feature which materially simplifies the construction. Moreover, by arranging the units in this way, the necessary paths are provided for the flow of the induced current, upon which successful parallel operation depends. The stator winding is so arranged that when the rotor speed is not synchronous, the currents induced in it produce mainly a magnetising effect, the restoring torque being developed by the rotor current. It has been found, we understand, that if a stator winding is used which permits the induced currents to flow mainly across the centre of the eight-pole winding, so as to provide a large restoring torque, the self-paralleling property of the machine is lost.



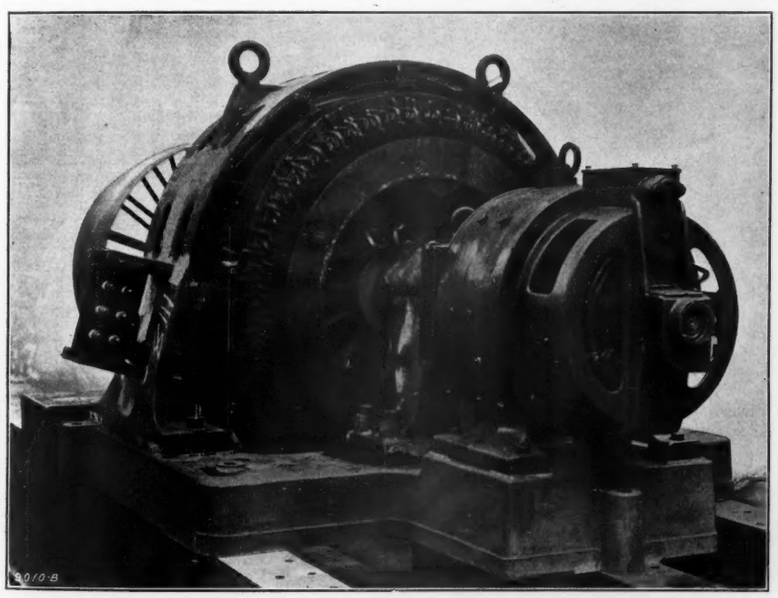


FIG. 4.

Two alternators of the type referred to have recently been put down to supply power to the Leckhampton Quarries, near Cheltenham, the machines having been constructed by Messrs. Sandycroft, Limited, of Sandycroft, near Chester, to the specification of Mr. H. D. Wilkinson, M.I.E.E., M.I.Mech.E., consulting engineer, of 56, Victoria-street, S.W. 1. Each of the machines, one of which is illustrated with its exciter in Fig. 4, has a full-load capacity of 160 kw. at a power factor of 0·8, and generates three-phase, 50-cycle current at a pressure of 440 volts. The machines are each directly coupled to a four-cylinder horizontal gas engine, constructed by the Premier Gas Engine Company, Limited, Sandiacre, Nottingham, and running at 250 r.p.m. Fig. 5, on page 724, shows the interior of the power house for the quarry with the two sets installed. Gas is supplied by two Crossley producers and the auxiliaries include an air compressor and receiver, exhaust fans, and circulating water cooling fans and pump, the cooling installation having been supplied by Messrs. Heenan and Froude, Limited, Manchester. The air compressor and exhaust fans, which are required for starting up the plant, are driven by a small oil engine, and the pump and fan of the cooling installation are operated by a 7½-h.p. motor.

The quarry, used for the production of limestone, is situated on a hill at a distance of about a mile from the power station, and to supply the motors there the voltage is stepped up to 2,200, power being transmitted at this pressure by an underground cable to a substation on the hill, where the pressure is stepped down again to 440 volts. Current is supplied from the substation to an 80-h.p. haulage motor, two 35-h.p. motors driving exhaust fans for lime kilns, a 7½-h.p. motor driving a kiln-furnace blower, a 4-h.p. elevator motor, and a 1-h.p. centrifugal pump motor. Stoneyard machines and an overhead crane, now practically completed, will require a total of 158 h.p. to drive them, and a hydrating plant, which will be installed

GAS-ENGINE DRIVEN SELF-PARALLELING ALTERNATORS AT THE LECKHAMPTON QUARRIES.

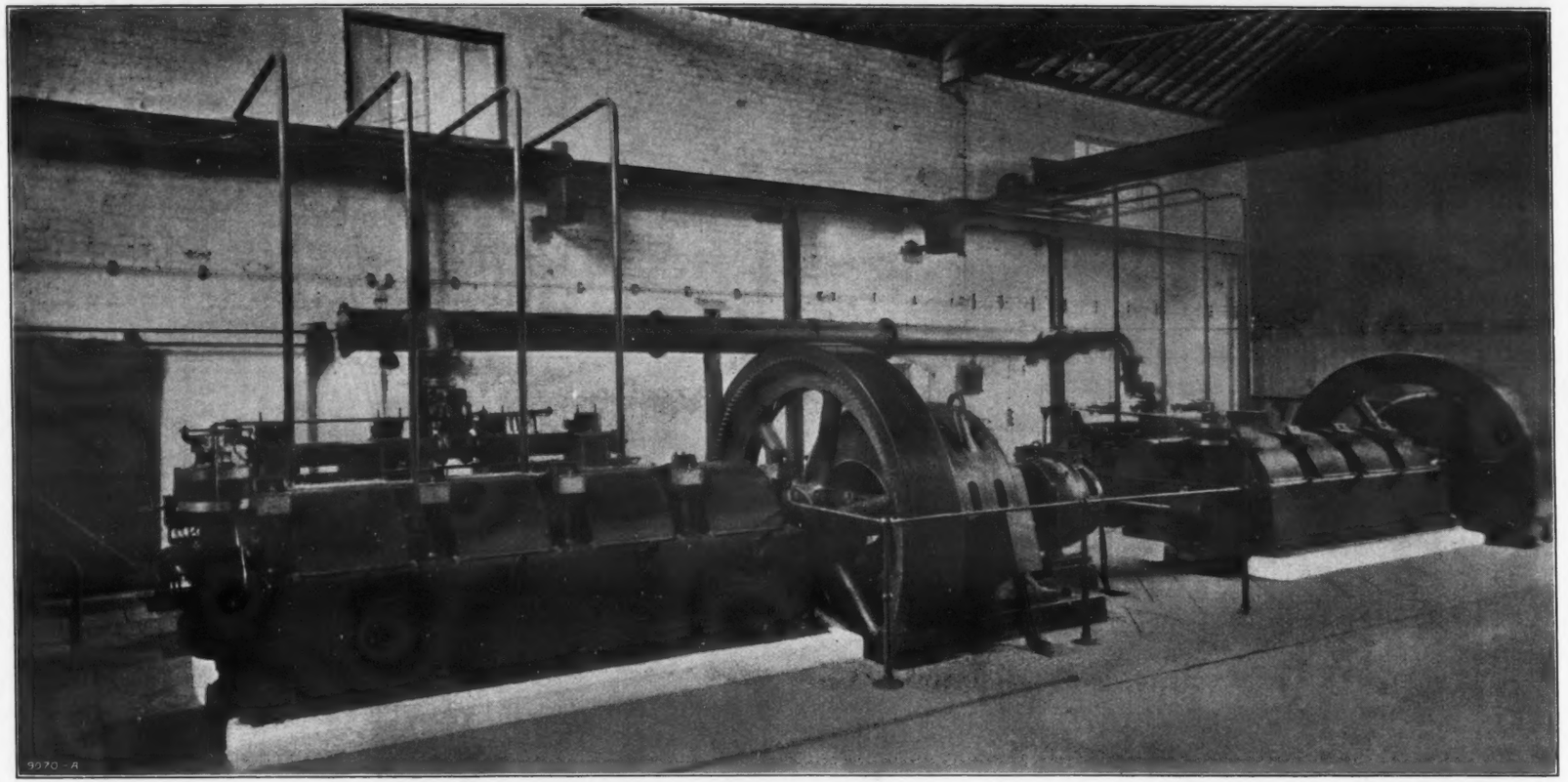


FIG. 5.

in the near future, will absorb another 120 h.p. The haulage gear, which is of the main and tail type, supplied by Messrs. Bullivants, Limited, 72, Mark-lane, E.C.3, controls the descent of trucks loaded with limestone, and the ascent of trucks which are sometimes empty and sometimes loaded with fuel for the kilns. These trucks run on a standard-gauge track and, on reaching a marshalling yard at the foot of the incline, are drawn by steam locomotives on to the main line of the Great Western Railway for dispatch. The difference in level between the two ends of the haulage system is 500 ft.

The haulage gear was designed to deal with two Great Western Railway trucks, each weighing 6½ tons, and being loaded with 10 tons, a total of 33 tons, on the down side, and either 23 tons or 15 tons on the up side, according to requirements. There would thus be an out-balance load of 10 tons, or 18 tons in favour of the gravity drive, but, as the gradient varies, it is actually necessary, in some places, to supply driving power. This occurs, for instance, when the descending load is nearly on the level and the ascending load is on the steepest gradient, where the inclination is 1 in 5. Considerable torque is also necessary to start the loaded trucks on the level before they commence to descend. The normal rate of travel, it should be mentioned, is 5 miles per hour. The haulage motor is an 80-h.p., single-speed, cascade machine of the type referred to above, designed by Mr. Hunt and constructed by the Sandycroft Company. It has been found to be quite capable of dealing with a 50 per cent. overload for short periods and with a 100 per cent. overload momentarily. The speed is controlled by mechanical brakes operating on the haulage drums and by regenerative braking on the motor, the latter method of braking coming into operation automatically when the speed of rotation of the motor exceeds the synchronous speed. The controller operates by regulating the resistance in the stator circuit, but when regenerative braking is in operation and the motor is returning energy to the line, the whole of the resistance is cut out. A Heenan and Froude hydraulic brake is included in the equipment as a standby for emergency use.

With regard to the efficiency of the power plant we may say that on a full day's trial recently made, using fuel with a calorific value of 14,670 B.Th.U. per lb., the consumption amounted to 1·27 lb. per kilowatt hour at 92 per cent. of full load and with a power factor of 0·98. At three-quarters of full load, the consumption amounted to 1·45 lb. per kilowatt-hour and at half-load to 1·53 lb., these figures, which were obtained after deducting the power used for engine cooling, viz., 6·6 kw., being materially lower than the guarantee.

Some particularly interesting tests, which we had an opportunity of witnessing, were also carried out to demonstrate the remarkable self-paralleling properties of the Hunt alternators. With the two sets at first running normally, one cylinder, and then two cylinders, of one of the sets were cut out, the machines remaining perfectly in step with one engine firing on four cylinders and the other on two. Continuing this test, the sets were run with three cylinders of each engine firing, and one cylinder of each engine was then cut out in succession, so that both sets were eventually running quite satisfactorily with only two cylinders firing. This test could not be carried further as the engines could not be operated with one cylinder only, but they

serve to indicate that, by employing self-paralleling alternators, the necessity for applying a very uniform driving torque is avoided, and the cost of constructing internal-combustion engines can therefore be materially reduced. These tests, we may add, were rendered particularly severe by the fact that the alternators were run on light load and that compression was taking place in the engine cylinders which were not firing. In subsequent tests, the machines were paralleled in exact phase opposition, and also with one machine running at a speed 2 or 3 per cent. below that of the other, without any ill-effects, and, although this would be unnecessary under ordinary working conditions, it will be obvious that the normal process of synchronising is an extremely simple matter.

In conclusion, we may mention that one of these alternators having a capacity of 210 kv.-a. and directly coupled to a four-cylinder, semi-Diesel engine, has been installed at the works of the British Steel Piling Company, Limited, at Gaydon, near Ipswich. It is running satisfactorily in parallel with an ordinary synchronous alternator of the revolving-field type, driven by a single-cylinder gas engine. Hunt alternators have also been employed in hydro-electric power plants and an interesting installation of this kind, at a mill in Scotland, may be briefly referred to. In this case, during the winter months there is plenty of water available and the machine, driven by a Boving hydraulic turbine, runs as a generator in parallel with the supply company's mains, power being delivered to the town when the mill is shut down. During the summer, there is insufficient water to drive the turbine, and the alternator is then run from the mains as a synchronous motor, driving the mills and also improving the power factor. At other times, the supply of water varies rapidly, and the machine changes equally rapidly from an alternator to a synchronous motor, and *vice versa*, without any signs of instability, the change being noticeable only by the reversal of the energy meter. The most obvious application for the new type of alternator, however, is in connection with internal-combustion engines, since these machines can be driven by single-cylinder or two-cylinder engines, and operated in parallel without any of the difficulties experienced in running synchronous alternators in this way.

EXTENSION OF STATE PORTS IN FINLAND.—The extension of State ports in Finland is being pushed ahead with considerable energy, and at Hangö the number of hands employed has been doubled. The new ice-breaking steamer which has been ordered from Holland has too great a draught for the old coal quay; it has therefore become necessary to build a new quay at the south-western corner of the Rotholmen. Another quay, 300 m. long, with other work, should be completed in the course of 1926. Another important State port extension work is going on at Björkö, where the new 200-m. long quay is almost finished. The depth alongside this quay with ordinary water level is 9 m. The vote for this work amounted to 11,000,000 marks F. and for the Hangö works to 13,000,000 marks F.

AMERICAN RAILWAY ELECTRIFICATION.—The announcement by the Chicago, Milwaukee and St. Paul Railroad Administration that as a result of operating electrically one section of the lines 438 miles in length during a period of over eight years, and another section 210 miles in length for nearly five years, a saving in running costs of 2,400,000*l.* has been achieved, will probably serve to encourage further main line conversion from steam to electric traction. The original investment in electrification amounted to 3,230,000*l.* Meantime the changing over of suburban lines continues, the Illinois Central Railroad authorities having decided to substitute this form of transport in place of the use of steam trains, over a distance of 27 miles, within the city of Chicago and in the immediate neighbourhood. A large expenditure is involved, and the cost of the electrical apparatus now being ordered will exceed 530,000*l.* The equipment will include 120 motor-cars and a similar number of trailers. A unit will consist of one motor-car and one trailer, and will be fitted with four motors, each of 250 h.p., so that a ten-car train will be nominally rated at 5,000 h.p. The New York Central Railroad Company has placed orders jointly with the General Electric Company and the American Locomotive Company for seven 100-ton electric switching locomotives and two 170-ton electric road freight locomotives, all intended for service in the vicinity of New York. Equipped for both overhead and third rail collection of current, these locomotives have been specified to handle a 1,500-ton train at a minimum speed of 25 m.p.h. in the case of those for switching, and in the case of the road locomotives a 3,000-ton train at speeds not less than 32 m.p.h.

THE ELECTRIFICATION OF THE IRISH FREE STATE.

(*Concluded from page* 695.)

THE scope of the whole scheme is perhaps best seen by referring to the proposed high-tension distribution network, shown in Fig. 14 (page 726). Schedules showing the exact run of both the 35-kv. and 10-kv. lines and the situation and type of the transformer stations will be found in the report. As appears from the particulars already given, the whole of the current is generated at the power station above Limerick at a tension of 10,000 volts, and is there stepped up to 110 kv. and 38·5 kv. The 110-kv. current is led through the centre of the country along what is called a busbar, consisting of a double line about 180 km. long to Dublin, and a single line about 93 km. long to Cork.* Each of these lines terminates in a transformer station, stepping down to 38·5 kv., and in the full development a fourth similar transformer station is to be provided at Maryborough. In the partial development the power station and the Dublin and Cork transformers supply the 35-kv. network, consisting of about 1,885 km. of line of various sizes, to which are to be added 83½ km. to the full development. The entire area is to be supplied from this network, except what is supplied in the neighbourhood of the power station at 10 kv. without transformation. Some supplies, such as those of the cities of Dublin and Cork, will be given at this voltage, and the distributing authorities will have to take the current from the transformer busbars, and to provide at their own cost such cables, transformers, converters and switches as may be necessary for the development of the service voltage at the city station. In the towns and elsewhere the voltage will be stepped down from the 35-kv. line to 10 kv. or the service voltage, according to circumstances. For the service of localities of minor consumption a network of 10-kv. lines is also provided, and will be extended considerably in the full development, in which it will be nearly as long as the 35 kv. The current is to be sold mainly or wholly in bulk, the locality being required to undertake both the capital and the working costs of distribution from the transformer on the network.

For the present purpose of providing an outline of the scheme it is unnecessary to follow in detail the modifications made in it by the experts. So far as concerns the constructional part, they take a more extended view of the embankments and drainage required by even the partial development. This adds to the cost, but as against this is to be set a substantial reduction in storage required in the stage. On the basis of estimates of probable demand they divide the storage requirements into three or four stages instead of two, in the first of which they propose to provide only 186 million cub. m., instead of 324 million cub. m., and obtain this solely by raising and lowering the levels of Lough Derg. At a second stage they similarly increase the storage capacity of Lough Rea, raising the total storage to 445 million cub. m., and at subsequent stages by further increasing the storage capacity of all three lakes they raise the total storage to 600 million cub. m. or 699 million cub. m., and finally to 827 million cub. m., as provided in the original scheme. For various reasons the experts suggest other alterations in the constructional designs and methods. The most considerable of these consist in reducing the cross-section of the head race (which is at once to be made adequate for the full development) to such dimensions as will allow a maximum speed of 1·5 m. per second instead of 0·91 m., as proposed in the original scheme, and to not making the tail race of the size needed for the full development until it is required. In this way over 250,000*l.* will be saved on the first stage, though navigation will be difficult or impossible on the occasions—said to be rare—when the maximum velocity is approached. A variety of alterations are suggested in the mechanical and electrical provisions, the most notable of which are an increase of the turbine and generating plant by substituting 30,000 h.p. and kv.-a. for the 15,000 h.p. and kv.-a. units and the provision of an extra 30,000-kv.-a. step-up transformer for the 110-kv. circuit. These alterations do not seriously affect either the scale of the work or the relation of its various parts to each other, and in considering these aspects of the scheme it will be convenient to adopt the figures given in the Siemens-Schuckert report.

Before, however, considering the general effect of the scheme as a solution of the problem to which it is addressed, attention must be drawn to the fact that authoritative exception has been taken to certain defects that are alleged in its fundamental design. The watershed of the Shannon has a heavy rainfall and much flat country, parts of which already are subject to floods. Economically the flooding of cultivated land is a costly occurrence, and the original scheme of Messrs. Siemens-Schuckert recognises the necessity not only of not increasing the liability of the district to flood but also of reducing it as far as possible. As mentioned above, the experts have made a considerable increase in the provisions against flooding. They have increased the embankments of the Shannon and provided drainage channels, and the terms in which they write appear to convey no concluded opinion as to whether even more should not be done than comes within the scope of their reference to recommend. The merits of this important question cannot be discussed satisfactorily without more information than is contained in the two reports under notice; but in the absence of such material, weight must be attached to opinions that have been expressed by, among others, Sir John Purser Griffith, the chairman of the Sub-Committee on the Water-Power Resources of Ireland, and Dr. H. H. Jeffcott, its secretary. Apart from their general professional experience, and from Sir John Purser Griffith's special acquaintance with bogs, such as border on the Shannon, both these gentlemen were engaged for upwards of two years on the study of possible water-power development in Ireland, and bring to the consideration of such a scheme as that now in question a combination of professional and local knowledge that is probably unique.

As will be seen later, each of them has objections to the scheme for the purpose for which it is intended; but even in the absence of these objections they condemn it as calculated to make a serious increase in the damages to be apprehended from floods, unless it is preceded by more extensive drainage works than the power scheme demands. The designs for these works are said to have been prepared, and the method of procedure reported on, by engineers of the first eminence. Sir John Purser Griffith has pointed out that the flooding of the Shannon is likely to increase as the drainage of the adjoining boglands improves, and in general that improved land drainage in a watershed enables water to flow more rapidly from the uplands into the river. Moreover, without adequate sluice capacity in the weirs, and the deepening of shoals in the channel of the river, the mere embanking of the river would only result in increased flooding within the embankments. Dr. Jeffcott remarks further that while no constructional details have been given to show that the embankments will be waterproof, no embankments can affect the percolation of water through the porous banks and bed of the river. It is through these that the river receives most of its contents at present. The topography of the district makes the hydraulic gradient small; as Dr. Jeffcott estimates it, perhaps a fraction of an inch in a few yards. In the new construction the top of the bank is to be crowned with an embankment, with a channel cut outside it; and the several feet of head thus produced must, it is urged, force a proportionately large quantity of water through the comparatively short length of porous bed and banks that lie between the river and the channel. Messrs. Siemens-Schuckert estimate that such loss will be of the order of 10 per cent. of the run off, and provide pumps to lift the water back from the channel into the embankment. Dr. Jeffcott, in this respect endorsing a fear expressed independently by Professor Thrift, believes, on the other hand, that the leakage will be far larger, and thinks that, unless the very expensive alternative of making the bed and banks watertight is adopted, the power required by pumps and motors of the

* These lengths are, of course, the distances between the terminal stations measured along the lines.

size provided is likely to be a considerable portion of the entire power generated.

On more general grounds the scheme has been criticised as inefficient and uneconomical—that is to say, as making imperfect use of the water power of the country, and paying needlessly much for such power as is obtained. To appreciate the grounds on which these objections are taken, it is first necessary to consider the nature of the problem that the scheme is meant to solve. The Irish Free State is estimated to have about 350,000 continuous e.h.p. of water power, practically all undeveloped, and distributed fairly well over most parts of the country. Its population is 3,100,000; so that the waterpower, if all developed, would only provide about 0·11 continuous e.h.p. per head. Speaking in very round figures, this power would, if the current were produced cheaply enough to enable it to be used wherever it was conveniently applicable, be about sufficient to satisfy the needs of the present population, without any allowance for the growth of population that should follow on so important a development of national resources. The country has to import its coal, and it is evident, therefore, that ultimately it will be unable to afford to waste any of its water power. At the present time it is wasting practically all of it, and in so far as its material development depends on the help of mechanical power the country is in a particularly backward condition. The experts mention that Dublin was one of the first towns in Europe to have a public electric supply, and in all there are 94 public supply works in various parts of the Irish Free State; yet the aggregate installed machinery is only about 27,000 kw., which works out at 0·013 per inhabitant of the whole country, or 0·038 per inhabitant of the districts in which the supplies are situated. The Government of the Irish Free State desires to use the national water power now running to waste, and to provide the country with the means of advancing in its use of mechanical and electrical help. The present scheme has been introduced as the right solution of that problem.

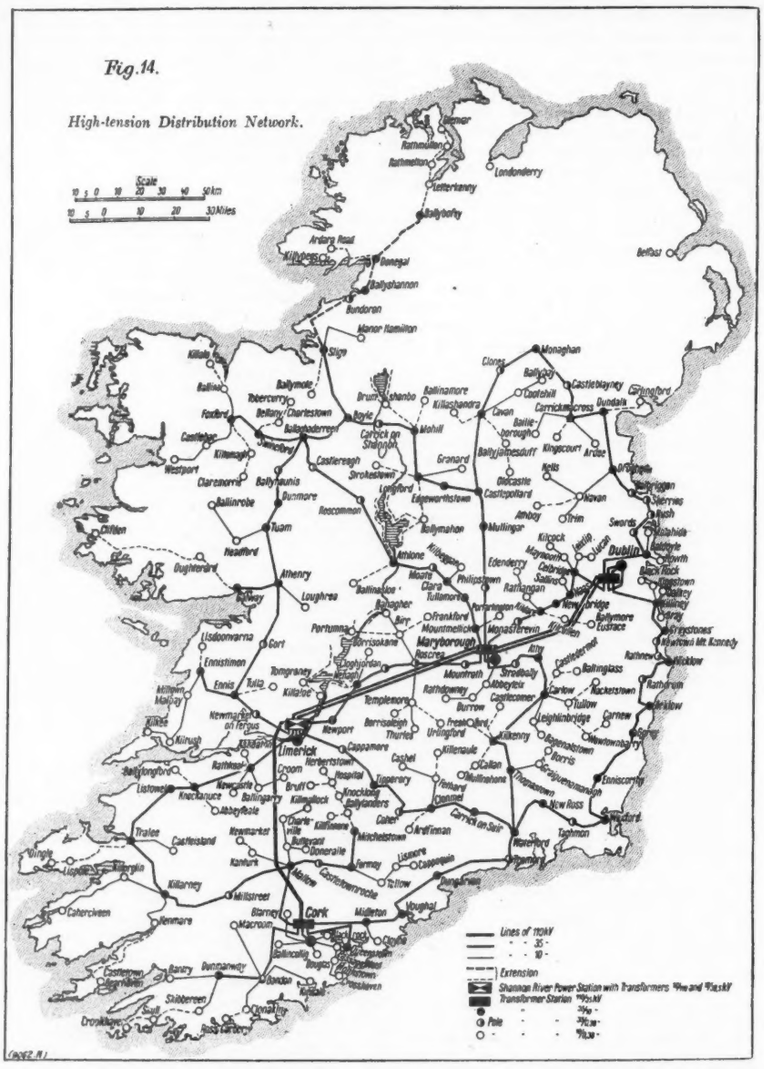
The ramifications of the proposed works have already been described in outline, and are shown collectively in Fig. 14. Their scale and the relation in which their several parts stand to each other may be indicated best by the round figures of their costs and the costs of their component parts. The total estimated cost of the partial development, including an allowance of 15 per cent. for interest during construction, is a little under 5,000,000*l.*, and of the full development a little under 7,000,000*l.* In the partial development about half the total cost is to be spent on constructional works, about 6 per cent. on generating and other power-house plant, and about 30 per cent. on transmission lines and transformer stations; the corresponding figures for the full development are about 54, 9 and 27 per cent. The cost of transmission plant is thus very high, both absolutely and relatively to that of the entire works; but it does not include the cost of distribution mains, nor for most of the working cost of transformation plant for use on the high-tension voltage at which the current is intended to be sold in bulk.

The same relatively high expenditure involved in the transmission service is shown in the estimates of operating costs, which give separately the estimated costs of current in the power house and in the several transformer stations. The estimated annual expenditure on the partial development is 489,000*l.*, of which over 90 per cent. consists of the interest and amortisation charges and expenditure on the transmission network and appliances. Dissected according to the situation of the areas of supply, the estimated cost of producing current at the estimated rates of consumption varies from 0·35*d.* in the power house to 0·85*d.* in the 10-kw. stations; no estimate seems to be given of the costs of distribution from the high-tension stations, though, like the cost of the plant for the purpose, these would doubtless be considerable in comparison with the corresponding figures for generation.* For the full development the estimated annual expenditure is £681,000—of which interest, amortisation and transmission take about 90 per cent, and the estimated cost of generating current for the estimated consumption varies in the several stations from 0·346*d.* to 0·769*d.* At present, of course, the figures for the partial development are of the more immediate consequence. The burden the transmission charges impose on the scheme, including, of course, line and transformer losses as well as interest on plant, may be realised by comparing the figures just given for the estimated costs of current in the power house with those for the transformer stations. Dr. Jeffcott, after quoting the figure of capital expenditure on the transmission plant, expresses the sum total of this burden by the remark that the transmission plant brings up the cost of operation from 280,000*l.* per annum—the operating cost of generation—to 489,000*l.*, while of the entire current generated at this inflated cost some 30 per cent. is to be wasted on full load, and more if the load should fall short of what is estimated. The report of the experts leads to a similar conclusion as to the order of magnitude of transmission expenses. For an initial consumption of 150 million units a year they place the cost of energy at the power station at 0·41*d.* per unit; but the best they can say for the supply to small towns is that it should show a very considerable reduction on the present prices, which, as they mention, vary from 6*d.* to 1*s.* 6*d.* per unit, being, as a rule, 1*s.*

The extent of these losses is not surprising when the figures given earlier for the transmission network are considered, and the lines themselves are followed on the map. The lines run as far as 225 miles on the 35-kv. and 10-kv. systems, and though this is an extreme instance, the distances to be run on the voltages provided—the voltages could, of course, not be increased without increasing the already large amount to be spent on transmission lines and plant—appear on the average to be extravagantly in excess of what is usual elsewhere. How much these lengths exceed what is thought prudent in the practice of other countries is shown in a pamphlet recently issued by Dr. Thomas MacLaughlin on this scheme, "with particular reference to electrical development in other lands." Dr. MacLaughlin, though his pamphlet does not mention the fact, appears from observations made last year in the Dail by the Minister for Industry and Commerce to be an officer of Messrs. Siemens-Schuckert, by whom the Shannon scheme was first introduced, both to that firm and to the Free State Government. The pamphlet commends the scheme to the Irish public eloquently and unreservedly, and it may be assumed that its statements at least do no injustice to the Siemens-Schuckert proposals. As a typical German system in a country comparable with the Irish Free State he selects the network over the province of Pomerania,

Fig. 14.

High-tension Distribution Network.



* The Siemens-Schuckert report contains also a suggestion for the provision of machines for a further 21,000 kw. for supply to chemical industries, which on the assumption that its output was all sold, would, of course, improve the load factor and reduce the costs. No allowance, however, is made for this plant in the summary of costs, and the experts express the opinion that the bulk chemical industries could not afford the price—0·35d. per kw.-hour—at which the report estimates that the current would have to be sold to them.

and illustrates it by a two-page scale map, showing the run of the lines and the distribution of the transformer stations. According to this map the country served by this network is a crescent-shaped area about 100 miles long by something under 30 miles broad, as against the proposed Irish network of about 270 miles by 160 miles. The Pomeranian network is fed at 40 kv., and its total length between stations is about 200 miles according to the map. Dr. MacLaughlin in an explanatory statement has thought fit to treble this figure. So far, however, from 40 kv. current being carried over anything like 200 miles, the line is fed from no less than nine independent power stations; and the map seems to show, as is consistent with these figures, that the greatest distance over which 40 kv. current is led in this system is between 20 and 30 miles, as against 225 miles for the 35 kv. network of the Siemens-Schuckert scheme. Incidentally, the proposal of the present scheme that the entire Irish Free State should depend on a single-power station—a proposal that recalls in a way the Emperor's aspiration that all Rome should have only one neck—constrasts strongly with Dr. MacLaughlin's typical German system, in which an area which he describes as half that of the Irish Free State—his map shows it as very considerably less—has nine independent sources of supply.

Taken therefore at face value, the estimated costs of electrical energy generated on this scheme include very high charges for transmission, which, both in interest on capital and in line and transformer losses; and these, assuming the estimates are realised, will have to be met by proportionate charges for current. Doubts, however, have been expressed and seem reasonable as to whether even these estimates are trustworthy. The cost of current will necessarily vary with the actual production, and questions have been raised as to the extent to which the consumption assumed in the estimates will be actually attained. At the present time the Free State is consuming something under 50 million units a year, and the estimates require that within two to three years this consumption should be more than trebled. No doubt can be felt that this would be possible if the current could be supplied at a suitable price and with suitable convenience to the consumer. For the purpose of estimating the prospect of increase comparisons of price must be made not so much with what has been paid hitherto as with the intrinsic value of the energy supplied. It must be expressed in terms of the labour it saves and the convenience it gives, and it must be in the important item of current supplied for industrial uses checked against the cost paid by competing manufactures in other countries. Local conditions may often prevent such comparisons from being conclusive. Different communities may be more or less ready to adopt innovations, or may be disposed or compelled to attach different values to saving of labour or gain of convenience. Industries may be able to pay more for their power if the market for their product is near at hand; the Free State, for instance, would have an advantage in this respect in an electrical manufacture of fertiliser. But considerations such as these, though they may modify the conclusions suggested by comparing the price of energy with its intrinsic value, can only do so within limits. If the consumption of electrical energy is to increase rapidly, it must be intrinsically cheap.

Figures such as those quoted above make it impossible for current supplied under this scheme to be cheap; and grave doubts have been expressed as to whether the supply will not be too costly on the average to prevent any growth of consumption as rapid as that assumed for the purpose of the estimates, and necessary to be attained if the current is not to cost even more than they allow. In the experts' report comparisons are made with the progress of other countries, and attention is called in particular to the extent to which electricity is used in Norway, though with the admission that circumstances are more favourable there to the production of cheap current. The example of Kristiania is cited to show how large a load can be obtained for merely domestic use. It must be remembered, however, that for the most part the prices of current with which comparison is made—in the case of Kristiania it works out at about ½*d.* per unit—appear to be for the current delivered to the actual user, while those of the estimates under the present scheme are almost entirely for the cost or charge in bulk, with the considerable cost of transforming to low voltages and delivering not included.

The actual average cost seems, moreover, in some danger of being overlooked through comparisons being based on the price to be charged to individual consumers, such, for instance, as the electrical authorities of Dublin, Limerick and Cork. In any scheme it is, of course, possible to make specially low charges to individual consumers, if the resulting deficit can be covered by higher charges to others. An essential part of the purpose attributed to the present scheme is to enable the entire country to share in the benefit of the development; and if the cities are to pay at one rate and the other parts of the country at rates not only greater but very many times as large, the scheme will presumably fail to accomplish the part of its purpose that is concerned with giving all parts of the country a fair share. At the present time, some 700,000 inhabitants are in districts that have a public supply, against three times that number who have none. The inhabitants of the parts that are not electrified at present should be put on the same sort of footing as those of the other parts for invoking the help of electricity in extending their agriculture and industries and promoting their comfort, if any reasonable effect is to be given to the excellent intention of developing the water power of the State for the equal benefit of all its inhabitants. On the other hand, such a development on a scheme with a single generating station for the whole country would involve the anomaly that for areas remote from the power station the State would be spending far more per unit on current than for nearer supplies. A Government can do much, but it cannot share energy that is available at one point among inhabitants distributed over an area of 26,000 sq. miles without some one paying for the cost of carrying it.

From the engineering point of view, the real question that arises on the desire of the Government to mobilise the country's water power is, however, not only whether the present Shannon scheme is technically and economically practicable, but whether it makes the most efficient use of the available water power. The scheme is the conception of an eminent firm of electrical engineers, elaborated after six months' study of the circumstances of the country and river, and revised by distinguished experts after a study of little more than as many weeks. As a solution of the problem to which the mind of the Free State Government is said to be addressed, which is the true problem from the engineering point of view, it ignores the much more prolonged study of the entire subject that was made by the Board of Trade Sub-Committee, with the assistance of experienced engineers, in addition to those included on the Sub-Committee. Their inquiries did not include the investigation of all the available sources of water power in Ireland, but they did include not only the Shannon, but the Liffey in the neighbourhood of Dublin on the east, the Erne a little above Sligo on the west, and the high-level lakes of Donegal, Connemara and Kerry in the west and Wicklow in the south-east, besides enumerating a considerable number of other rivers in various parts of the country, with the horse-powers that are running to waste in them. They recommended the immediate development of the Shannon, Erne, and Liffey on lines already worked out, and suggested further the investigation of certain other rivers as well as the lakes, which, in their opinion, were likely to furnish ready sources of additional power, able to be developed at relatively small costs. Each of these schemes would enable the developed power to be used in the neighbourhood of the power stations, and thus supply the needs of a large part of the country without serious losses in transmission.

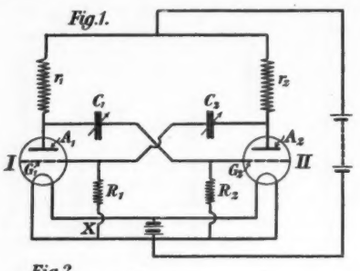
The works to which the report of the sub-committee referred had, moreover, been so designed that they could be constructed and extended step by step as the demand was secured, and would not have to be built speculatively on the mere faith of estimates. The network of transmission lines by which the systems of towns were to be connected would thus become balancing lines, carrying surplus current from one system to another, the main work of each system being done in the neighbourhood in which the current was generated. Dr. Jeffcott contrasts the Siemens-Schuckert scheme with others examined by his sub-committee. The Shannon scheme of Mr. Theodore Stevens, for example, was to be carried out in four separate generating steps without the construction of head or tail races. It was estimated when fully executed to yield 343 million units in an average year at a capital cost at the present time of 2,100,000*l.*, while the revised Siemens-Schuckert scheme is to generate 198 million units—or 288 million including power available only in the winter—at a capital cost of about 3,340,000*l.* The other schemes, so far as they have been developed, appear to have the same qualities of providing more current at less cost, supplying adjacent areas without heavy transmission costs, and being designed to be constructed in a number of stages, corresponding with realised demand. The Siemens-Schuckert Shannon scheme transmits its current from Limerick right across the country to districts where the power stations of these alternative supplies would be found. Ultimately it must put the country in a dilemma of which either alternative will be costly and wasteful. Either the energy in these other sources will have to be left undeveloped and the power absorbed in transmission from Limerick will continue to be wasted, or in the better event interest will have to be paid on the heavy cost of transmission lines that will have become useless and need never have been made.

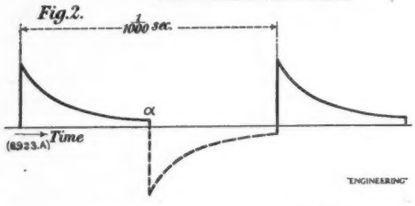
The Government of the Irish Free State in their sagacious and enlightened desire to develop the water-power resources of their country have undertaken no light matter. If the power is used to the best advantage, the benefits of the development will apply not to one but to all districts equally, and not be concentrated on selected spots. The whole success or failure of the mobilisation of water power will depend on the selection of the right scheme. The considerations outlined above show something more than doubt whether the present scheme makes the most efficient use of the available power, and even whether it does not threaten actual mischief. The consequences of a mistake will handicap the development of the country for a generation or more. It is difficult to believe that questions so momentous, raised as they have been on competent and disinterested authority, will not receive more deliberate consideration than can have been given in the few weeks that the experts were able to devote to the consideration of the Siemens-Schuckert scheme. Dr. Jeffcott expresses the earnest hope that the Free State Government will set up a small committee of Irish engineers to consider the whole question, before embarking on a costly project that must hinder the full economic development of the country. The Government has considered the Siemens-Schuckert proposals at first hand and in considerable detail. The scheme is certainly open to the objections pointed out above, but this does not show that the alternative schemes may not be defective in other and more serious respects. What Dr. Jeffcott asks is, that they shall be considered in the same detail, and a considered comparison made. He says that with the information already available a trustworthy decision could be reached in a comparatively short time. This doubtless is important; but from the engineering point of view, what seems even more important is to ascertain whether the grave disadvantages of the present scheme are really unavoidable.

THE DYE STANDARD MULTI-VIBRATOR WAVEMETER.

THE frequencies and wave-lengths of electric oscillations can be determined by indirect and by direct methods. Most of the portable wavemeters belong to the former class and depend upon the adjustment of inductance and capacity so as to bring the two circuits into resonance or synchronism. These instruments are easily operated and are adaptable, but the original calibrations are liable to change

with time. Direct measurements of high frequencies can be effected in three ways: by the aid of high-frequency alternators, by the photography of luminous discharges reflected by revolving mirrors, and by harmonic methods. In harmonic methods frequencies are built up or down in order to obtain exact multiples or sub-multiples of the standard frequency. Since that was first done, nearly twenty years ago, in the Reichsanstalt, when the theory of harmonics in the Poulsen arc was developed, various harmonic methods have been worked out, and the accuracy of the measurements has been greatly increased by the introduction of valves. One of the most reliable sources of harmonics devised for producing known radio frequencies was the multi-vibrator described by H. Abraham and E. Bloch in the *Annales de Physique*, 1919. Mr. D. Dye, of the National Physical Laboratory, makes use of this vibrator for his standard multi-vibrator wavemeter, which, having proved of great service in that Laboratory, has been placed upon the market by Messrs. H. W. Sullivan, Limited, of Winchester House, E.C. The instrument, the design and specification for which were provided by the National Physical Laboratory, was one of the exhibits of the firm at the Physical and Optical Societies' Exhibition of last January. Our diagrams, Figs. 1 to 4 on this page, will help to explain the principle of the wavemeter.

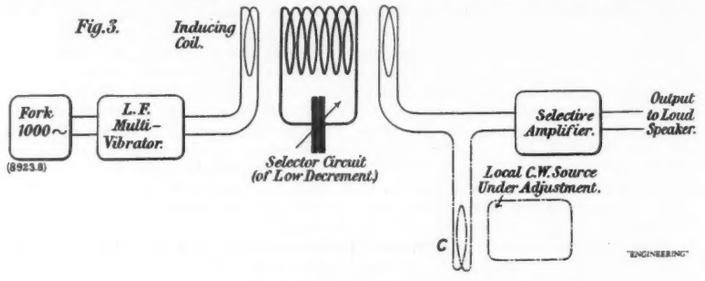




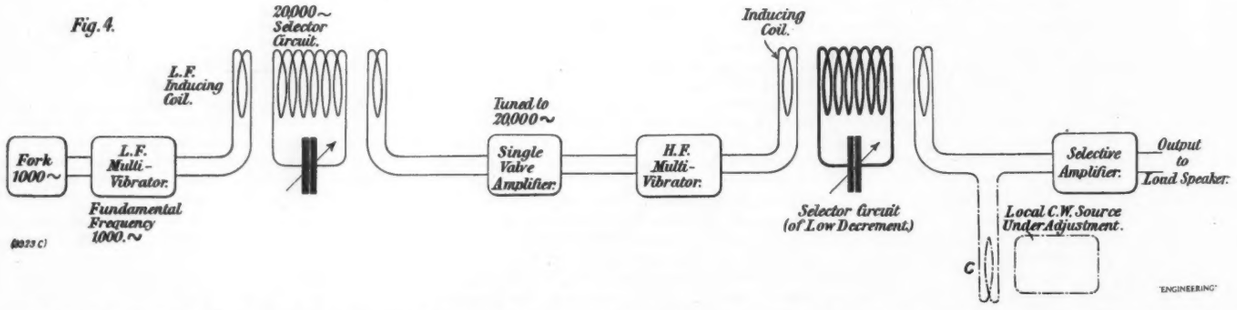
This is briefly as follows:—A pair of valves, cross-connected as indicated in Fig. 1, is used to generate low-frequency oscillations at 1,000 cycles per second and of the wave form illustrated in Fig. 2, which wave form includes numerous harmonics. The fundamental frequency, and consequently also the frequency of the harmonics, is accurately controlled by means of an electrically-maintained tuning fork. A coil carrying the low-frequency oscillations is magnetically coupled to a selector circuit containing an inductance and a variable capacity, so that it can be tuned to respond to any one of the harmonics, up to the 120th, present in the low-frequency oscillations. The selector circuit thus forms a source of approximately sine-wave oscillations of frequencies which are multiples of the fundamental and these oscillations, amplified in a selective valve amplifier, can be used to calibrate a local source of oscillations, such as a heterodyne wave-meter, by the heterodyne-beat method. For higher frequencies than 120 kilocycles, two selector circuits, arranged as shown in Fig. 4, are employed. The first selector circuit, energised by the low-frequency, fork-controlled circuit as before, is tuned to the 20th harmonic and the oscillations of 20 kilocycles frequency are amplified and applied to a high-frequency valve multi-vibrator. The oscillations from this are applied to the second selector circuit, which is tuned to the desired harmonic and the high-frequency oscillations are compared with the local source of oscillations as mentioned above. Frequencies up to 1,200 kilocycles, corresponding to a wave-length of 250 metres, are obtainable in this way. It should also be pointed out that intermediate frequencies between the main harmonics can be obtained by synchronisation beating between certain heterodyne beat notes and difference tones due to interference between the beat notes and a permanent residual note having the same frequency as the tuning fork. When using the high-frequency multi-vibrator, sub-harmonics occur when the local source is varied off the setting of exact synchronism, giving other standardisation points between the main harmonics.

The apparatus is contained in three boxes. The low-frequency vibrator (Fig. 1), the tuning fork (not illustrated) and the high-frequency multi-vibrator fit into the first box, as is indicated in Figs. 3 and 4; the second box contains the selector circuit and its inductance coils; the third box contains the selective amplifier. There is, fourthly, the local source under adjustment or test shown at the bottom of Figs. 3 and 4. The tuning fork is made of elinvar, a nickel steel of a very small temperature coefficient of elasticity, and is cut from a wide, flat bar of the material, so as to leave a large cross section of metal at the root of the prongs. The clamps are made heavy in order to minimise any vibrations of the whole fork mounting; the complete tuning-fork equipment weighs about 10 lb. The fork is calibrated by the aid of a phonic motor and a standard clock. One of these forks forms the foundation of the radio-frequency standard of the National Physical Laboratory. The ends of the prongs lie between the cores (laminated iron-wire bundles) of two coils, the cores being polarised by permanent bar magnets of tungsten steel, which form two sides of a rectangular frame, 14 cm. by 10 cm., about the fork. The two coils form the anode and grid circuits of the maintaining valve. The two valves governing the low-frequency multi-vibrator are coupled—symmetrically except in one respect, as shown in Fig. 1—to generate a discontinuous current of a fundamental frequency of 1,000 cycles and of the wave form of Fig. 2. There is an output winding coupled to the anode coil. The fundamental frequency of the wave depends essentially upon $(C_1R_1 + C_2R_2)$ and is adjusted by varying the capacities of the small condensers C_1 and C_2, which are shunted across larger condensers not indicated in the figure. The resistances r_1 and r_2 also influence the frequency.

The want of symmetry just mentioned arises from the coil X (Fig. 1), which is inserted in the grid-leak circuit of valve I only; the diagram Fig. 2 indicates the current variations in this coil, which are similar to the potential variations between grid and filament. At the instant a, the potential of grid G_1 has become strongly negative and has caused the anode current in valve I to drop almost to zero, and the potential of the grid G_2 is therefore high. The potential of the grid G_1 now gradually rises towards zero due to the leakage through R_1 of the charge on G_2 and G_1. Before zero potential is actually reached, anode current begins to flow again in valve I; thus the anode potential at A_1 is lowered, and this diminution is transferred *via* the condenser C_1 to grid G_2. The result of this fall of potential in G_2 is a decrease of the anode current of valve II, which increases the potential at A_2. The consequent rise in the grid potential G_1 accelerates the increasing anode current in valve I; finally, G_2 becomes sufficiently negative, as a result of the increased potential fall on r_1, to reduce the anode current in valve II to zero; the cycle then recommences.



For the measurement of radio-frequencies up to 120 kilocycles (Fig. 3), the coupling coil already mentioned (the low-frequency inducing coil of Fig. 3) is inserted in series with the one grid leak in order to induce into a selector circuit of low decrement consisting of a special low-loss variable air condenser of high permanence and a number of air-spaced interchangeable coils. The variable condenser is designed directly for an even scale of frequency, and is therefore provided with vanes of a special shape; it is also shielded in a German-silver box to eliminate the effects of stray capacities. The selector circuit may be tuned to select any desired harmonic, and the harmonic thus reinforced is induced into another coil connected in the input circuit of a four-valve selective amplifier consisting of one radio-frequency amplifying stage (tuned-anode coupled), a detecting stage, and two low-frequency amplifying stages. The selective amplifier not only amplifies the harmonic chosen, but also the continuous oscillation with which it is required to heterodyne, and which is superposed upon the harmonic through the medium of the further coupling coil C. When adjusting a local source of oscillation by means of the standard wave-meter, using the low-frequency multi-vibrator, the heterodyne beat is heard from the loud speaker. In addition, however, at exact synchronisation with the selected harmonic (*i.e.*, when there would ordinarily be silence) a note of 1,000 cycles is heard, due partly to direct coupling from the multi-vibrator and partly to rectification by the selective amplifier of the modulated current in the selector circuit. This residual 1,000-cycle note facilitates the calibration by providing further synchronising beats, when the source is varied off the exact synchronisation point. When frequencies above 120 kilo-cycles are required, a second vibrator, the high-frequency multi-vibrator (Fig. 4), is set operating in order to supply to the inducing coil impulses of a fundamental frequency of 20 kilocycles, from which harmonics up to the 60th can be selected giving frequencies up to $60 \times 20{,}000 = 1{\cdot}2 \times 10^6$ per second; the corresponding minimum wave-length (for this type of instrument) would be 250 m. For this range of frequency, another series of three inductance coils of low decrement is used.



The high-frequency multi-vibrator has itself to be synchronised in the manner indicated in Fig. 4. The low-frequency multi-vibrator of 1,000 cycles, synchronised by the tuning-fork, not being required in this case to energise the low-decrement selector circuit, is made to induce into another selector circuit which is tuned to select the 20th harmonic of the low-frequency multi-vibrator fundamental, *i.e.*, 20,000 cycles. This reinforced harmonic is then amplified by a single valve having its anode circuit tuned to the harmonic frequency, and the energy of the amplified 20,000 cycles frequency is then used to control the high-frequency multi-vibrator, the latter being brought within the range

GANDY VIADUCT ACROSS TAMPA BAY, FLORIDA.

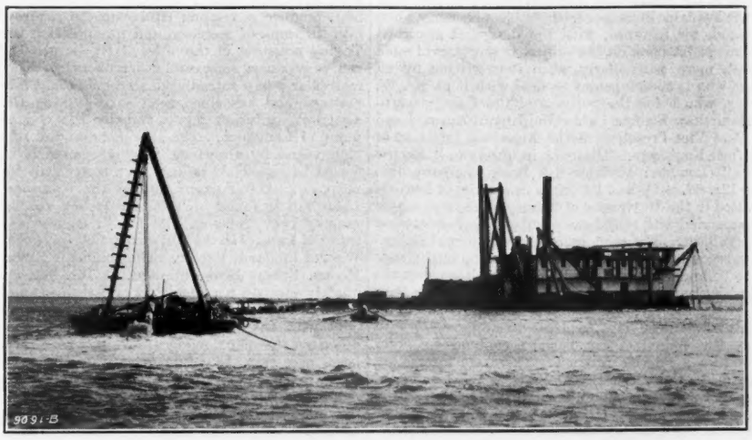


FIG. 1. FLOATING PIPE LINE.

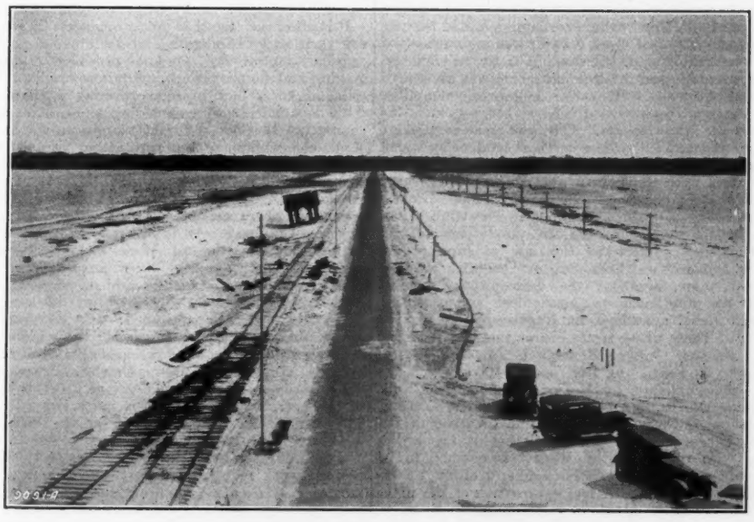


FIG. 2. EASTERN CAUSEWAY.

synchronisation by coarse and fine filament-current regulation.

When the high-frequency multi-vibrator is used for measuring frequencies above 120 kilocycles, sub-harmonics occur when the source is varied off the setting of exact synchronism with the selected harmonics, and the subharmonics supply intermediate standardisation frequencies between the main harmonics, which are then 20,000 cycles apart. It requires some skill to interpret what is actually being heard.

The multi-vibrator wavemeter is a laboratory instrument of the portable type. The fundamental accuracy can be checked by redetermining the frequency of the tuning fork, which probably gives greater steadiness than is securable by other means.

THE GANDY VIADUCT.

TAMPA Bay, on the west coast of Florida, U.S.A., is a large body of water running some 30 miles or so inland. Two important towns, Tampa and St. Petersburgh, are situated on either side of it, and previous to the construction of the Gandy Viaduct, with which this article is concerned, connection between the two places was possible only by water or by a long detour around the bay. The distance across the water between the two towns is some 6 miles, and the fact that the viaduct has been constructed to cover this distance, at once makes it clear that the structure is of an unusual and interesting type. Incidentally, nothing perhaps could better illustrate the place which the motor-car has taken in the transport problem in the United States than the fact that the structure has been planned and built as a motor-car toll bridge. The work owes its origin and takes its name from Mr. George S. Gandy, who conceived the idea more than 20 years ago, and has seen it brought to completion almost entirely as a result of his own work and enthusiasm.

The structure, of which the centre part only is a bridge proper, consists of three sections—two sand-filled causeways which jut out from either shore, and a central reinforced-concrete structure, which spans the deeper water in the middle of the bay. The western causeway is rather more than 2¼ miles long, the eastern causeway a little more than ¾ mile long, and the central concrete bridge section 2½ miles long. The first surveys to settle the best position for the viaduct were made in 1915, and line surveys were made from several different locations on the shore north of Port Tampa, which is situated some 8 miles from Tampa proper. This work was interrupted by the war, and although some survey work was carried on in the following years it was not until after the termination of the war that it was possible to start work on a serious scale. The surveys resulted in the discovery of a broad bed of rocks in the middle of the bay, the eastern half of which was covered by an overburden of sand, several feet deep, and it was decided to erect the bridge in such a location that advantage could be taken of this rock bed for the foundation.

The deep water across the middle of the bay had an average depth of 10½ ft., with a maximum of 23 ft. at the main channel, at which point a draw-bridge has been incorporated in the structure. Soundings taken in connection with the survey work showed that the shoals extending from both shores of the bay contained sufficient sand for dredging purposes, and it was the presence of this material that decided the method of construction of the sand-filled causeways. The average depth of water over the sand flats was little more than 1 ft. The construction of the sand-filled causeways was first taken in hand, and in September, 1922, the pumping of the sand to form the causeway on the St. Petersburgh side was started. Two months later similar work was started at the Tampa end of the site. The work was carried out by a fleet of suction dredgers with sand pumps, which delivered the sand by a floating pipe line as shown in Fig. 1, annexed, which shows one of the dredgers at work. The dredgers at first deposited a ridge of sand along the line of the causeway to a height just above high water, and then worked back over the line and brought up the banks to an elevation of 10 ft. above mean low-water. The causeways slope from the roadway to the beach and have a minimum width at the base of 400 ft. A view of the eastern, or Tampa, causeway is given in Fig. 2. In all, a total of 2,500,000 cubic yards of sand was dredged from the bottom of Old Tampa Bay.

For work in connection with the building of the concrete bridge, a large construction camp was established on the eastern shore of the bay, and was completed in the spring of 1923. A service railway 2½ miles long was laid connecting the camp with the Port Tampa line, and with deep water at the end of the eastern causeway, where a 1,100-ft. pier was built for the transportation and handling of materials and bridge parts. A plant was established at the camp for casting reinforced-concrete piles, and the first concrete was poured on May 15, 1923. This plant continued in operation until October, 1923, and completed 2,400 piles. The piles were all 16 in. square, and varied in length from 20 ft. to 60 ft. A view of the pile-casting plant is given in Fig. 3 on Plate XLVII; the bending plant, in which the pile-reinforcing rods were formed, is illustrated in Fig. 4. The plant was built up from boiler plates, and the bending was carried out by air-brake cylinders from freight cars.

During the period that the construction camp was getting into operation, two floating drill barges of the Layne South-Eastern Company were drilling the rock bottom, to determine whether the bed of rock was a solid mass at all points along the line of the bridge, or whether it was in any place merely a thin crust. This test showed the foundation to be entirely satisfactory, as holes were drilled to a minimum depth of 11 ft. at distances of 150 ft. along the site and at no place was the rock penetrated. The piles were driven from floating pile-drivers, the first being put in place in July, 1923. In the eastern part of the bay the piles were driven through sand to the rock, some of these piles penetrating sand to a depth of 45 ft. The large quadruple pile-driver which was used, drove four piles at a time, utilising water jets and a steam hammer. In the western part of the bay, where the rock bottom was not covered by an overburden of sand, the piles were placed in drill holes by a quadruple drill barge. These piles were set in the rock to a depth of 5 ft. or more. The piles were driven in groups, or bents, of four, spaced 5 ft. apart between centres, across the line of the bridge, and the bents were spaced 24 ft. apart. Fig. 5 shows a large number of piles in place, but the arrangement in groups of four is perhaps better illustrated in Fig. 9.

The piles were aligned and braced by timbers, and were then cut off to length by hand tools, pneumatic tools or explosives. The reinforcing rods were cut by oxy-acetylene burners. Owing to the fact that the concrete was of very good quality and that the work had to be done over water in all kinds of weather, the cutting-off operation proved a very tedious job. A view of part of this cutting-off operation is given in Fig. 6. After the pile heads had been cut to length, wood forms from the concrete caps were clamped in place, the reinforcement was inserted and the forms were filled from barges and the smaller of two floating concrete plants. A view showing some of the forms in place and some of the caps already cast, at the eastern end of the viaduct, is given in Fig. 7. The pier to the right of this figure is the deep water service pier connected by rail to the construction camp, which was referred to above.

On the completion of the caps, wood and steel forms for the deck beams and slabs were placed in position. These were floated out on barges and lifted in place with screw jacks. The steel reinforcement was then inserted and the beams and slabs were cast from the large floating concrete plant which is illustrated in Fig. 8. The last deck span was cast in July, 1924. This large floating plant was capsized in 20 ft. of water during an unusually severe north-west gale in the winter of 1923-24, and several weeks were lost in raising the hull and re-equipping the plant for work. In the deck of the bridge, the top slabs and supporting beams were cast integral in units of eight spans, giving a

length of 192 ft. between expansion joints. There are in all 70 expansion joints at which the deck beams slide over steel bearing plates. The total expansion of the bridge, between the extremes of summer and winter temperatures, amounts to some 5 ft. A view of part of the bridge after the completion of the main decking is given in Fig. 9.

As has already been mentioned, this concrete bridge is 2½ miles long. It is 24 ft. wide on the road surface between curbs, and is provided with reinforced-concrete railings, as shown in the view of the east end of the completed bridge given in Fig. 10. There are altogether 3,500 rail posts on the bridge. Over the main channel, towards the eastern end of the bridge, there is a steel double bascule drawbridge, giving a clear opening of 75 ft. for the passage of ships. The foundations of this drawbridge, which was built by the Tampa Shipbuilding and Engineering Company, consist of eight reinforced-concrete cylinders 5 ft. in diameter, set in the rock bottom and topped with heavy blocks of concrete. The drawbridge is electrically operated and the main bridge is electrically lighted throughout its entire length. The main bridge was designed by the Raymond Concrete Pile Company and the drawbridge by the Strauss Bascule Bridge Company. The total cost of the entire work was something over 600,000*l.*

NOTES ON NEW BOOKS.

THERE is no class of worker to whom a knowledge of mensuration is of more practical value than to the blacksmith or metalworker, and a book entitled "*Metalworkers' Practical Calculator*," written with the object of providing information on the subject, is required to be at once very simple in treatment, concise, and inexpensive. The volume thus entitled, written by Mr. J. Matheson (Sir Isaac Pitman and Sons, Limited, price 2*s.* net), admirably fulfils these requirements. Divided into two sections, the first part of the book is intended to serve as a refresher course in the fundamental operations in arithmetic. Careful readers of this section will notice that a slip has crept into the working of Example 11 on page 9, but this does not affect the answer to the problem there solved. In Example 11 on page 15 a mistake has been made in dividing 7·75 by 12, and at the bottom of page 16 the fraction corresponding to 17½ per cent. is given as $\frac{7}{10}$. These errors are all obvious, however, and should give rise to no difficulties. Part II contains a carefully selected collection of illustrated worked examples, together with answers to exercises, and tables of the weights of different materials. Errors appear to be absent throughout this section, and the useful hints provided should assist in ensuring a place for the book among current issues of this class.

While we concede that the definition and classification of "bitumen" is controversial, we should not choose that term as a collective name for what is generally called petroleum. Mr. I. A. Stigand, M.A., F.G.S., hesitated whether to put the term bitumen in the title of his "*Outlines of the Occurrence and Geology of Petroleum*" (London: Charles Griffin and Co., Limited; price 10*s.* net), and he discusses what is usually designated the genesis of petroleum under the heading "Origin of Bitumen" in his first chapter; in the subsequent chapters he speaks of petroleum. In these he deals with the stratigraphical distribution and the accumulation and concentration of petroleum in relation to geotectonic conditions, with the problems concerned in oil movements, with oil-reservoir rocks and petroliferous strata and with direct indications of petroleum. The appendix, on geographical methods as applied to oil-finding, is by Dr. M. Mühlberg, of Aarau, Switzerland, apparently a translation of a German contribution. This appendix describes the use of the Eötvös torsion balance, which is now to be tried in England, and refers particularly to the work of J. Koenigsberger (whose assistance is acknowledged) and H. von Boecch, in Hungary. The appendix further notices magnetic surveying, as applied by F. Schuh in the Mecklenburg salt district; the electric survey of C. Schlumberger, of Paris, which is based upon conductivity measurements in the soil, and their dependence upon the moisture distribution, stratification and faults; the determination of seismic and acoustic wave propagation by different rocks, as utilised by the L. Mintrop, of Bochum; and underground temperature and other methods of soil investigation. The sections are short, but supplemented by literature references, as also is the main body of the volume which is offered as "an introductory handbook." We do not know that the reader will learn much from the pages in which he is told, for instance, that the Miocene occurs in Borneo, Java, North-east China, New Guinea, and some eighty or more other districts of the world, all of which are named.

The literature on the subject of the manufacture of electric cables has been lacking in certain directions. Whilst it is freely admitted that we hold the premier position in the production of cables, it must be confessed that the available literature on the subject is scanty when compared, for instance, with the design of electrical machinery. A book on the subject is therefore of some interest, more particularly when it is written by an author who is so competent to deal with it as Mr. W. Delmar, who holds the position of Chief Engineer to the Habirshaw Electric Cable Company of America and is a Past Vice-President of the American Institute of Electrical Engineers. The book in question, "*Electric Cables*" (London: McGraw-Hill Book Company Inc. Price 12*s.* 6*d.* net), had its origin in a series of lectures delivered in the University of Pennsylvania, and can be recommended with confidence to all engineers interested in the subject. The economical transmission of electricity is becoming a matter of ever-increasing importance to the community, and it will be appreciated that the subject is one which demands careful study. The book deals with the manufacture and design of cables in a simple manner, and explains the difficulties with which the manufacturer has to contend in order to produce a reliable product. There are interesting chapters on the dielectric strength of the insulation, waves and surges in cables, insulation failures, and the present voltage limits. In this latter chapter, the author states that the dielectric strength is now the crux of the problem, but that successful results have been obtained with a normal operating pressure of 66,000 volts between phases.

Leonardo da Vinci, whose surname afforded the peg for a famous *mot* of Mark Twain, was undoubtedly a very remarkable man. He was an artist, an engineer, and a scientist, and in all departments was abreast of the best of his age. His career, moreover, exemplifies once again a distinctive difference between scientific and artistic achievements. The great creative thinkers in pure and applied science serve as ladders by which humanity in general attains to higher levels than the originators were themselves able to reach, with the result that pioneering achievements soon become almost solely of historical interest. The triumphs of the artist, on the other hand, are purely personal and are thus not subject to the law of supersession. Hence Leonardo's "Last Supper" retains all its original value, save for the defacements of time, whilst his note-books on mechanical and scientific subjects have, nowadays, an interest merely for the curious. Those whose tastes incline this way will read with pleasure "*The Mechanical Investigations of Leonardo da Vinci*," by Dr. Ivor B. Hart, which has just been published by Messrs. Chapman and Hall, Limited, at 16*s.* net. The work includes a useful discussion of the state of mechanical science in the fifteenth century, and the translation of Leonardo's MSS. "On the Flight of Birds" is claimed to be the only complete translation of any of his manuscripts into English. A large proportion of the notes on flight are of the nature of vague suggestions, and to credit their author with providing any real assistance to the actual solution of the problem would be to commit the same error as that by which the popular Press attributed the invention of the "tank" to Mr. Wells. From some of Dr. Hart's quotations it would appear that da Vinci had a very good idea of some important principles of statics and dynamics.

The Hoepli handbooks in the Italian language constitute in themselves a most complete library, covering the arts, sciences, and practically every trade and industry. The last two to reach us deal with a branch of industry which has made, of late years, great progress in Italy, namely, electrotechnics and electro-metallurgy. One, entitled "*Elettrotermica*," is by Dr. Romoli-Venturi, and is a theoretical and practical treatise intended for all who are engaged in the design, construction and working of electrical heating apparatus. It contains an introduction on mathematics and physics, followed by chapters on heat, electrotechnics and electrothermics; chiefly relating to domestic heating, although a few particulars are given of the application of the electric current to industrial purposes—for melting, heating, annealing, and so forth. The price of the book is 15 lire. The second book, having for its title "*L'Altoforno Elettrico*," is by Dr. F. Pagliaro, and takes for its subject the electric smelting furnace, which it deals with in detail. It reviews the various types of furnaces—resistance, arc and induction—both from the electrical and the metallurgical standpoints. Its price is 12·50 lire. Both handbooks are carefully printed, and very neatly bound. They can be obtained from Mr. Ulrico Hoepli, Milan.

It is common knowledge that extraordinary improvements have been effected, during recent years, in the technique of producing very low pressures. The imperfections of the appliances necessarily used by such pioneers as the late Sir William Crookes enhances our appreciation of the results they succeeded in attaining. Even in capable hands, the old Sprengel pump could, at best, produce a vacuum equivalent to a pressure of, say, 10^{-5} mm. of mercury, and its operation was slow. To-day pressures of the order of 10^{-7} mm. of mercury can be produced in several different ways. The Gaede molecular pump introduced a new standard into these matters, and has since been surpassed by the same designer's diffusion pump and by the condensation pump of Langmuir. The Dewar method of producing high vacua by absorbing residual gases by charcoal cooled in liquid air is also very convenient for some purposes. A full description of these various appliances will be found in "*The Production and Measurement of Low Pressures*," by Dr. F. H. Newman, Professor of Physics in the University College of the South-West of England, Exeter. The volume is published by Messrs. Ernest Benn, Limited, at 16*s.* net, and adequately meets a need which was daily becoming more pressing. As its title indicates, the work deals not only with the production of low pressures but also describes the many modern devices with which it has been necessary to supplement the McLeod gauge. This instrument provided for many years the only reliable means for measuring low pressures. To-day the most varied phenomena are impressed into this service. Some of the gauges described by Dr. Newman depend for their action on gaseous viscosity, or on the heat conductivity of a gas, whilst, in other cases, ionisation phenomena are made use of.

It is often the case that young engineers, in planning out their early education and training, neglect the consideration of the essential processes of pattern-making and foundry work. Advisers are often much to blame, for a lack of some training in the work of these departments of engineering work is a serious handicap. It is not sufficient to rely on the abilities of the men who make the patterns or moulds, if the costs of production of machines are to be reduced. The successful designer must have a knowledge of how the job is to be tackled in the works, before he can appreciate where economies may be effected in the design. The next best thing to actual experience in pattern making is the acquisition of knowledge of its processes by the careful study of accurate works written by authorities on the subject. Among these, Mr. Joseph G. Horner's well-known book on the subject is to be recommended. Its value may be appreciated from the fact that "*Pattern Making—a Practical Treatise*" is now in its fifth edition. The book is published by Messrs. Crosby, Lockwood and Son, Stationers' Hall-court, London, E.C.4, at a price of 18*s.* net. The new edition is much larger than the last; new matter has been added and the illustrations now total more than six hundred. It covers an extensive field, ranging from elementary constructions to the pattern work required for gear wheels and machine moulding.

In teaching elementary science in evening classes and in junior technical schools, it is necessary that the treatment should be such as to show the relationship of the subject to practical work. The needs of the students must be the first consideration. Not everyone can afford the time necessary for the study of every detail of fundamental theory if they are to acquire a reasonable knowledge of specialised technical work in the few years at their disposal for the purpose. It is therefore necessary that text-books should be available which bridge the gap between pure theoretical treatment and the authoritative works on technical subjects, in the readers of which a knowledge of the important theory is assumed. A happy medium in balancing theoretical work with the more elementary technical matter is provided in "*Junior Technical Electricity*," which Mr. Robert W. Hutchison, M.Sc., has written for the University Tutorial Press, Limited, of High-street, New Oxford-street, London. This work, which is sold at 4*s.* 6*d.* net, is intended to give the reader a clear insight into the fundamentals of electrical theory and a thorough grounding in the elements of electrical engineering. Nothing that is learned from it will have to be discarded when the studies of a student carry him into the higher stages of his technical work. Great care has been shown by the author in giving accurate definitions and numerous worked out examples in each chapter add to the value of a book which will be welcomed by teacher and student alike.

Instruction in metal-colouring has been given in some of our technical colleges for several decades, and books on the subject have come from these institutions. The latest contribution to this literature is "*The Chemical Colouring of Metals*," by Samuel Field and Samuel Robert Bonney (London: Chapman and Hall, Limited; price 10*s.* 6*d.* net). Both the authors are at the

Northampton Polytechnic Institute, Mr. Field as head of the Technical Chemistry Department, and Mr. Bonney as instructor in metal-colouring and finishing. The book opens with general notes on chemistry, some of which could well be spared, and the work would benefit by excision in other directions. Nobody is likely to study metal-colouring without having an elementary knowledge of chemistry. One of the two literature references which we have found in the book quotes Vernon's report on the tarnishing of metals as having brought out, for the first time, that a corrosion film may be protective, neutral, or detrimental—a fact which was known, of course, long before Mr. Vernon's valuable report appeared. The main chapters on the methods of colouring metals mechanical, thermal, chemical, and electrolytic), their cleaning and lacquering, and on the tools and processes used, are to the point. It may be the best plan to discuss the processes in the order of the metals to be treated—copper, brass, silver, gold, zinc, iron, &c.—but some systematic treatment of the reactions might have been attempted. That "black copper ox" and "silver ox" are both sulphide coatings and have nothing to do with oxidation, for instance, is only pointed out when silver is discussed. It is stated that only *verde antique* shades were used up to 1828, when the Florentine bronze (bronze Lafluer) began to appear in France. Stoves for Florentine bronzing were described by Debonliez in 1827, not as anything novel, and powdered gold and other bronzes of Huber, of Fürth (near Nürnberg), were famous by 1750. More care might have been bestowed upon the index, which does not mention the Florentine bronzes and many others duly described in the book.

Particulars of the warships of the world, their tonnage, speed, armaments, protection, builders' names, date of construction, &c., are contained in the "*Taschenbuch der Kriegsflotten*," 1924-25, by Captain B. Weyer, now issued at the price of 10 marks, by J. F. Lehmann's Verlag, Munich. Representative types forming part of the navies of different nations are illustrated, the illustrations including diagrams showing the distribution of the armour and armament. This constitutes the main portion of the book and is followed by a reproduction of the special clauses in the Versailles Treaty concerning German naval power. Data, in tabular form, are then given on the naval guns built by different firms, and owned by the various maritime nations. A separate chapter contains remarks, principally of a political nature, on naval matters generally, on which there is no need for us to comment. The book closes with tables giving figures relating to merchant fleets and with the usual conversion tables.

COMBINED DRILL AND REAMER.—Two patented tools—one a combined twist drill and reamer, and the other a taper-pin reamer drill—have recently been introduced by the Stalker Drill Works, Limited, of Drill-square, Langsett-road, Sheffield. As the name implies, the combined drill and reamer performs two operations at the same time. Made from high-grade high-speed steel, it has four flutes and the diameter of the drilling point is ground slightly smaller than the desired finished size. The face of each land, instead of being continuous, is divided up into a series of cutting faces by notches disposed in left-hand helical lines, forming as it were, narrow subsidiary left-hand flutes. These cutting faces perform the reaming operation and freely cut away the metal left by the under-size point. A round hole with smooth parallel sides, correct to the required dimension, is thus produced. It is claimed that the tool can be operated at ordinary high-speed drilling rates. The four-fluted taper-pin reamer drill is similar in design, and the underlying working principle is apparently identical.

THE OIL TANKER "INVERROSA."—The Inverrosa, one of a group of four shallow-draught, oil-carrying vessels ordered by Messrs. Andrew Weir and Co. from Messrs. Harland and Wolff, Limited, for the Lago Shipping Company, Limited, was recently handed over to her owners by the builders. This ship is 315 ft. in length, 50 ft. in breadth and has a gross tonnage of some 2,400. She has been built to the requirements of Class 100 A.1 of Lloyd's Register, which apply to vessels designed for the carriage of petroleum in bulk. There are eight bulkheads, oil- and water-tight, dividing the boat into nine compartments, while five oil tanks are provided. Oil-fuel bunkers have been arranged abreast of the boilers. The vessel has a straight stem and elliptical stern and is rigged as a one-masted fore and aft schooner. Engines of the twin-screw, triple-expansion type, developing 1,100 indicated horse-power, are fitted, the steam supply being generated in two cylindrical single-ended boilers working at a pressure of 180 lb. per square inch. Each boiler has three Morison furnaces arranged to burn oil fuel on White's system under natural draught. The air, circulating, feed, and bilge pumps are driven off the main engines. Two 5-kw. electric-generating sets are provided and these supply some 100 points, together with power for a number of electric fans installed throughout the ship. After completing trials in the Belfast Lough, the Inverrosa proceeded to Aruba, an island off the coast of South America, where she will be put into service.

LETTERS TO THE EDITOR.

BENDING-MOMENT ENVELOPES IN CONTINUOUS BEAMS.

TO THE EDITOR OF ENGINEERING.

SIR,—Might I draw your attention to a matter which is often propounded in text-books, although very seldom correctly? Indeed, I have seen only one correct set of curves, given in E. Suenson's "Jaernbeton," the results in other text-books being quite wrong both in principle and in figured values.

For every system of continuous beams carrying a uniform superload it is usual to give three curves showing:—

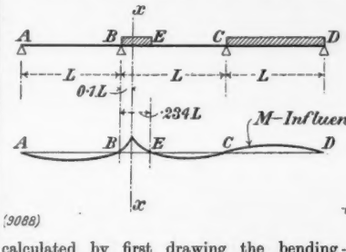
(*a*) A coefficient for the dead load moment (in terms of wL^2), *i.e.*, the moments caused by a uniformly distributed load covering the whole system.

(*b*) A coefficient for the maximum positive moment at all points caused by a uniformly distributed load covering parts of the system, deliberately arranged to give the maximum possible moment at every point *seriatim*, *i.e.*, the envelope of maximum positive moments.

(*c*) A similar curve showing the envelope of greatest negative moments.

These three curves are connected by a very simple relation (which few writers appear to know) the proof being as follows:—

The bending-moment influence line for any one point in a continuous system is a curve which is either positive or negative for loads placed at all points of the system, except for isolated points where it crosses the zero line. There are no parts of the system where the bending-moment influence line remains at zero value for any appreciable length. The value of the envelope (*b*) at any chosen point is



calculated by first drawing the bending-moment influence line for that point, and then loading all those parts of the system for which this bending-moment influence line has a positive value. Similarly, the value of the envelope (*c*) is calculated by loading all parts of the system for which this bending-moment influence line has a negative value, *i.e.*, by loading all those parts of the system not covered by the loading for curve (*b*). The loadings for (*b*) and (*c*) must together cover the whole system, and therefore the sum of the bending moments (*b*) and (*c*) must be the bending moment caused by a load covering the whole system, *i.e.*, the sum of the coefficients for (*b*) and (*c*) at any point must equal the dead-load bending-moment coefficient (*a*).

It follows also—

(i) If curves (*a*) and (*b*) are smooth curves, then curve (*c*) is a smooth curve.

(ii) If curves (*a*) and (*c*) are discontinuous at any point (as at a point of support), then curve (*b*) will also probably be discontinuous at that point.

It will be seen that all these principles apply also to beams carrying concentrated loads at fixed points (*e.g.*, say, at the third points of each span).

An example will make the matter clearer: Take a uniform beam of three equal spans L, and choose a section xx distant 0·1 L from a centre support B, as shown in the figure. The bending-moment influence line for section xx is as shown in the lower part of the figure, cutting the zero line at A, B, C and D and also at point E, which is 0·234 L from B. The very greatest positive moment that we can cause at xx by spreading a uniform superload w over the system, occurs when the beam is loaded from B to E and from C to D, and is found to be $+ 0{\cdot}015\ wL^2$. Similarly, the largest negative moment occurs when the beam is loaded from A to B and from E to C and is $- 0{\cdot}070\ wL^2$. Add these two loadings and we have the system loaded from end to end and a moment of $- 0{\cdot}055\ wL^2$ at xx, giving our dead-load bending-moment coefficient.

Examples of incorrect results will be found in several standard text-books.

The remarkable similarity between the curves given in these works points to the fact that the authors have all copied them from the same incorrect source (Winkler?), without making any effort to check the values. Notice particularly the incorrect "peak" value of $+ 0{\cdot}007\ wL^2$ given for the value worked out in the figure, the impossible "wobbles" in the curves for four equal spans, and the general violation of all the principles proved above.

Yours faithfully,

G. P. MANNING.

51, Craven-avenue, Ealing, W.5.
June 1, 1925.

ELEMENTS OF MAGNETIC ANALYSIS.

TO THE EDITOR OF ENGINEERING.

SIR,—In 1924, Dr. E. H. Crapper published a series of articles in your journal on the "Elements of Magnetic Analysis." In the second article of the series, on page 601 of vol. cxvii, Dr. Crapper says:—

"A very noticeable feature in connection with the fact that permeability is a variable function of flux density was, for a long time, the difficulty experienced in formulating an expression giving the quantitative variation in the values of permeability with increasing values of flux density B, in anything like a rational formula, and the difficulty was first solved by Lamont in 1880, when he introduced the idea of magnetisability . . . he suggested the theory that "the value of permeability of a magnetic substance is proportional to the difference between the saturation value . . . and the actual value of flux density B . . . or algebraically

$$\mu = K\ (B_s - B).$$

The quantity $(B_s - B)$ . . . obviously represents the magnetisability of the material for the condition under consideration."

From the magnetic literature in my possession at the present moment, I find that the law

$$\mu = K\ (B_s - B)$$

was formulated by Professor Bosanquet in 1886 (*Electrician*, 1886, page 247). Thus far I have not come across any earlier announcement of the law in this form by any one else. Bosanquet had also noted that this law was merely another form of Frölich's law.

In 1867, Dr. Lamont formulated (*Handbuch von dem Magnetismus. Kap. I. Natur des Magnetismus*, page 41) the theory that the rate of progress of magnetisation was proportional to magnetisability

$$dB/dH = a\ (S - B).$$

In 1886, Professor Silvanus P. Thompson tried to reproduce Lamont's theory in a form acceptable to the English reader; in interpreting Lamont's theory, Thompson referred to dB/dH as "permeability." According to Thompson's understanding, Lamont's theory is that "permeability" is proportional to "magnetisability." Professor Thompson's version of Lamont's theory is a correct interpretation if the word permeability be understood in the special sense of dB/dH; it is quite incorrect if the word "permeability" be taken in its conventional and universally accepted sense of B/H (see *Phil. Mag.*, 1886, page 8).

This was my understanding of the history of Frölich's law until I came across Dr. Crapper's paper. According to this paper, the equation $B/H = K\ (B_s - B)$ was first formulated by Dr. Lamont, and must have been published in 1880, that is, shortly after his death (Munich, August 6, 1879). Thus far I have met with no reference to that paper. I should, therefore, appreciate very highly any help which Dr. Crapper can give me in this connection.

Incidentally, I may take the liberty to call Dr. Crapper's attention to an oversight; in the passage quoted above, the words beginning with "the value of permeability," &c., are obviously quoted from Dr. Lamont's paper, but the end of the quotation is not obvious; it is difficult to say where the original quotation ends and Dr. Crapper's explanation begins.

Yours very truly,

S. L. GOKHALE,
General Engineering Laboratory.
General Electric Company, Schenectady, N.Y.,
May 27, 1925.

LARGE AUTOMATIC ELECTRIC GENERATING STATIONS.—The construction of an automatic electric-generating station, which when completed will be the largest of its kind in America, has been undertaken at the Soft Maple location of the Northern New York Utilities Company, near Watertown, in the State of New York. Designed to supply power at 66,000 volts pressure, this station will be provided with two 10,500-h.p. units, controlled from the Taylorville generating station 15 miles distant, starting and stopping being carried out by switching on and off the current in the transmission line connecting the two stations. Another large automatic station to be built is that of the Lawrence Power Corporation at Potsdam, N.Y. Two 3,200-h.p. units will be installed, and power will be transmitted at a pressure of 88,000 volts. Both of these new stations are hydro-electric, and will be constructed by the General Electric Company of America.

SELF-ADJUSTING PRECISION LEVEL.

CONSTRUCTED BY MESSRS. E. R. WATTS AND SON, LIMITED, LONDON.

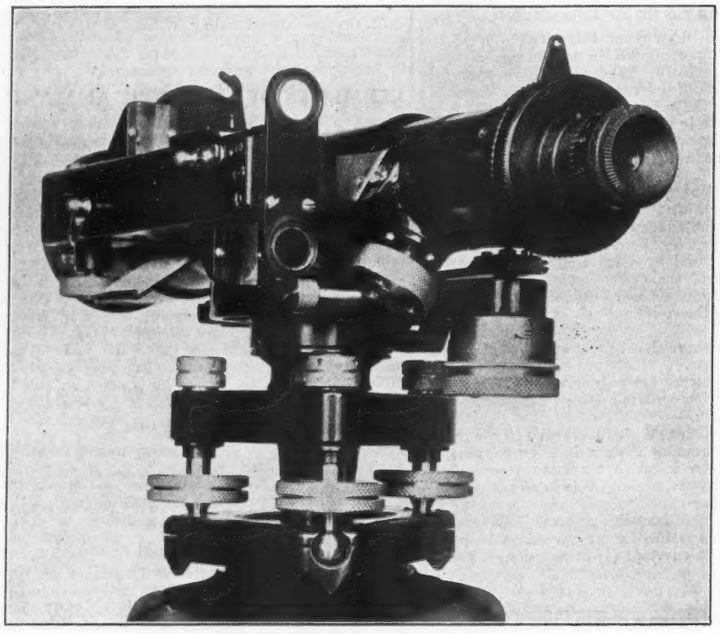


FIG. 1.

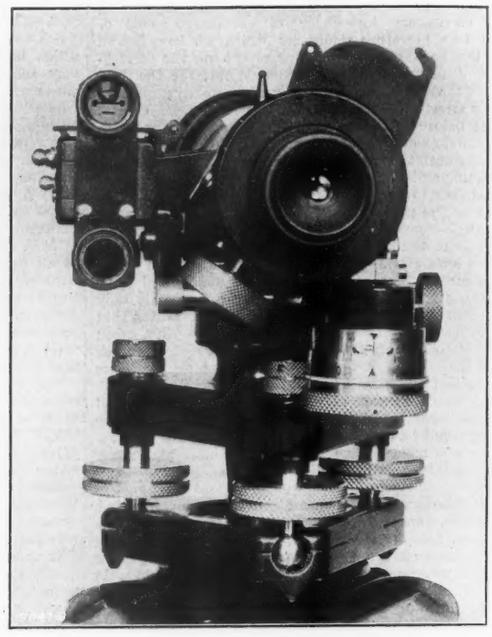
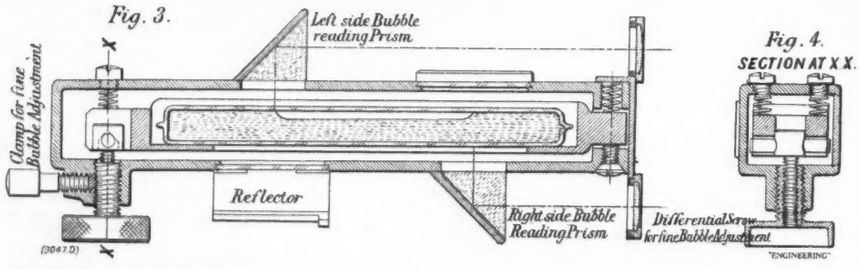
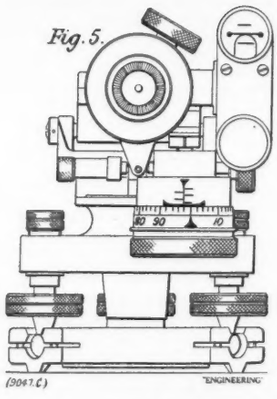


FIG. 2.





SELF-ADJUSTING PRECISION LEVEL.

WE illustrate on this page a precision level made by Messrs. E. R. Watts and Son, Limited, 123, Camberwell-road, London, which is so conveniently designed that it is a common practice for its users to test daily the accuracy of the line of collimation, since only a few seconds are required for the operation. The instrument is, moreover, fitted with a bubble, of which the length remains invariable even under the most drastic conditions, being the same in the depth of a Canadian winter as in the height of the summer. The telescope is, moreover, fitted with the internal system of focusing, which is now tending to become universal. The eyepiece is focused on the "cross-hairs" by a screw motion, and these "cross-hairs" are lines beautifully engraved on a glass diaphragm, which can be readily replaced if broken. The width of the lines adopted depends on the use to be made of the instrument. In special work the thickness is $\frac{1}{6000}$ in., but most surveyors find a thickness of $\frac{1}{4000}$ in. more suitable.

Two views of the instrument are reproduced in Figs. 1 and 2 above, whilst further details are illustrated in Figs. 3, 4, and 5. The telescope body is a solid gun-metal casting, having a parallel middle body accurately finished, and by this the telescope is supported in a long gun-metal sleeve, with which it makes a nice fit. It is held by shoulders from axial motion, but can be rotated in its sleeve through 180 deg. It is this arrangement which permits of the instantaneous checking of the line of collimation, since if this be correct, the telescope will give the same staff reading in both positions.

A delicate spirit level is carried on arms which form part of the telescope-body casting. The position of the bubble is read from the eye end of the instrument by means of a lens and prism, as best seen in Fig. 3. The appearance of the bubble, as seen by the user, is well indicated in Fig. 2, which shows the level on the left-hand side of the instrument. To check the collimation, the telescope is rotated so as to bring the level to the right-hand side, and the bubble then appears as indicated in Fig. 5; the staff reading should be the same in both positions.

As already mentioned, the bubble is of constant length. Each tube is numbered and sent for test to the National Physical Laboratory, whose certificate as to the constancy of length under a wide range of temperatures accompanies each instrument. This long-awaited desideratum has been secured by reducing the pressure, due to expansion, to a point where it exactly balances the effects of surface tension. This constancy of length involves a secondary convenience in that the surveyor has only to observe one end of the bubble at a time; and, in fact, the instrument is so constructed that he cannot see both. When the end of the bubble corresponds exactly with the fiducial mark shown in Fig. 2 and in Fig. 5, the line of sight is level. To secure accuracy in the location of these fiducial marks, the makers employ a special machine which reads by micrometer to half a second of arc. In this machine the bubbles are reversed through 180 deg. and the tubes graduated accordingly.

The method of mounting the bubble is illustrated in Figs. 3 and 4. The tube is cemented into a gun-metal carrier, as indicated. One end of this carrier is pressed by a spring down against a single-pointed screw, whilst the other end is formed with a V-notch into which engages a cross-bar forming part of the head of the central member of the differential screw shown. This is, perhaps, best seen in Fig. 4. The use of a differential screw facilitates very fine adjustment, but if, as is sometimes done, a feather is relied upon to prevent the rotation of the inner member, it is very difficult to avoid some amount of backlash. As shown in Fig. 3, a clamp is provided for locking the bubble bearer after the necessary adjustment has been made.

In the same figure, a reflector is shown below the tube, and this reflector directs light up through the bubble to the prism, which in its turn reflects the light to the eyepiece. This reflector is constructed as a hinged flap, and when the telescope is "reversed" by rotating it in its sleeve a second flap opens automatically and reflects light through the other end of bubble tube, whilst the flap previously in use closes down.

Two cross-levels, of moderate sensitiveness, are provided for use in the "rough" levelling of the instrument, and a pair of sights are also fitted for the rough alignment on the staff. The fine adjustment is then made. This is effected, as to level, by tilting the telescope by a differential screw, of which the operating head is, perhaps, best seen in Fig. 5. The use of a differential screw for this purpose provides a relatively large motion of the head for a very small tilt of the telescope, whilst backlash between the components is guarded against by a modification of the arrangement used for the bubble-tube adjusting screw, as already described. The adjusting head, it will be seen, is provided with scales for setting off gradients. Each division corresponds to a slope of 1 in 50,000. A tangent screw is fitted to give a fine adjustment in azimuth. The milled head for this can be seen to the right of Fig. 2.

For use with this, or other precision levels, Messrs. Watts supply a machine-divided level staff. In this the graduations are incised into the wood instead of being merely painted or stencilled on. The accuracy of the divisions is guaranteed to 0·01 in., and since

FOUR-SPINDLE PLANO-MILLING MACHINE.

MESSRS. KENDALL AND GENT (1920), LIMITED, GORTON, MANCHESTER.

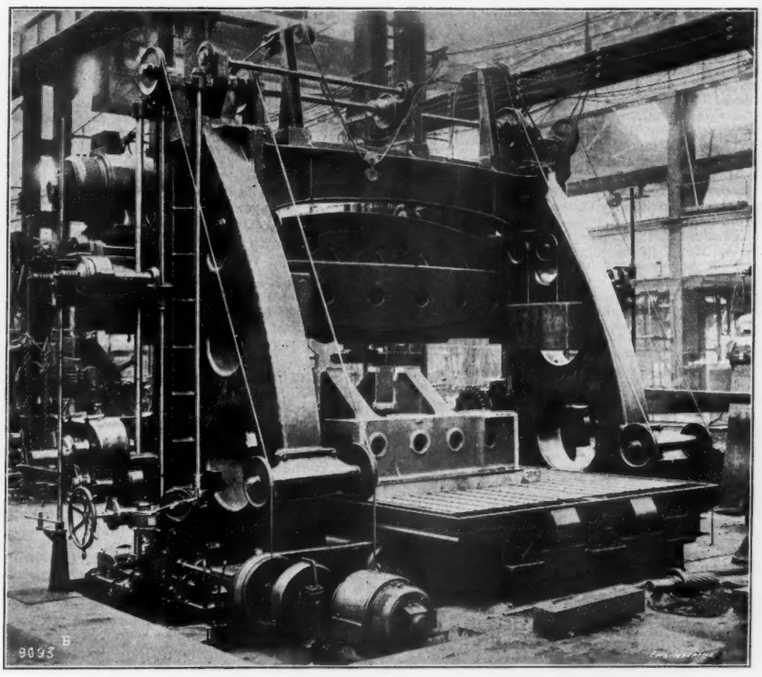


FIG. 1.

the scale is actually cut into the wood, it cannot be obliterated by accidental scraping or scratching of the surface.

In conclusion, it may be added that Messrs. Watts make a speciality of that precision work for which the metropolitan area is now acquiring an international reputation. They make all parts of their instruments, including the optical work and the castings, for which new metal only is used, the scrap being sold. Their principal dividing engine was completed a little before the war. It took nearly two years to complete, and, when finished, a circle was divided on it and sent to the Reichsanstalt for test. The test took nearly four months to carry out, and the maximum error found at any part of the circle was 1·8 second of arc.

FOUR-SPINDLE PLANO-MILLING MACHINE.

THE large four-spindle plano-milling machine, which we illustrate above and on page 736, has been built by Messrs. Kendall and Gent (1920), Limited, of Gorton, Manchester, for the North-Eastern Marine Engineering Co., Limited, Wallsend-on-Tyne. It has been designed for machining sections of large Diesel engine beds, but may readily be adapted to other classes of heavy work. As will be seen from Fig. 2, each vertical upright carries a spindle head, and two others are carried on the cross slide. The two side heads can be connected by a horizontal mandrel in the usual way for slab milling, the intermediate supports, in this case, being carried on the cross slide. Equally, either of the side heads may be utilised for driving a shorter horizontal mandrel, while the other is retained for face milling.

Dealing with the heads carried on the cross-slide first, each of these spindles is driven by an independent 35 h.p. motor; the method of mounting the latter on a bracket forming part of the head can be clearly seen in Fig. 2. The spindles are balanced by springs, and each head is fitted with a slow variable feed, and quick-power motion on the cross-slide. The feeds and traverse motions are independent, and it is impossible for the two saddles to come accidentally into contact, a safety device being provided on the feeds to prevent this. Each vertical spindle is provided with a range of power feeds, and in addition to the various power motions, both the saddles may be independently adjusted by hand, the controls for this purpose being brought down to a convenient position at floor level. The cross slide carrying the vertical saddles is of massive construction. It is some 28 ft. long, and its weight, which with the saddles amounts to about 28 tons, is partly balanced, the cables for this purpose being clearly seen in Fig. 1.

Turning now to the side heads carried on the vertical uprights, both heads are driven by one variable-speed motor of 60/70 h.p., which is mounted at ground level on one side of the machine, and coupled to the first driving shaft by spur gearing. The heads are fitted with both variable feeds and quick-power traverse, the control being independent or simultaneous as required. Both heads are balanced, and are provided with independent stop motions to the spindles. As in the case of the cross-slide saddles, the heads can be adjusted by hand, and this feature also applies to the cross-slide itself, the motions, in every case, being either independent or simultaneous as required. All the power feeds and quick traverses are driven by an independent constant-speed reversing motor of 20 h.p., which is coupled direct to a change-speed gear-box. A number of different feed speeds can be obtained, the quick-power traverses being at a constant rate.

The bed of the machine is 33 ft. long, and the machine can deal with work up to 12 ft. wide, 18 ft. long, and 8 ft. high. The table is 12 ft. 6 in. wide, and has the longitudinal T-slots machined from the solid. It runs on three bearing ways, and is provided with substantial retaining strips, both on the outside and the inside of the bed. The traversing motion is obtained by twin worms, gearing with two semi-circular racks, and an equalising motion is provided in order that both worms may automatically take equal loads. The worms are fitted with heavy ball-thrust bearings to reduce friction and eliminate back-lash.

The spindle motors were supplied by the Sunderland Forge Company, Limited. The motor for the horizontal spindles has a speed regulation of 3 to 1. The control panels were supplied by Messrs. Brookhirst Switchgear, Limited, of Chester, and are of the automatic starting type with push-button control. They are fully equipped with safety devices, and a sparkless and full-face control is provided on each step of the starting resistance. The retarding device to govern and regulate the starting time is of the eddy-current type. The push-button controls are placed in convenient positions, and enable the operator to stall, stop, inch or reverse every motion on the machine with the minimum of exertion. All gearing throughout the machine is of steel, with the exception of the first driving pinions and the wheels with which they engage, these being of compressed paper and cast iron, respectively. All shafts and screws are of 35/40-ton steel. The total weight of the machine is about 160 tons, and when working at its full capacity with all four spindles in action, it is capable of removing about 160 cub. in. of cast iron per minute.

EXHIBITION OF INVENTIONS.

IN past years the Institute of Patentees has held a private exhibition of members' inventions, to which those who were likely to be interested were invited. This year the decision has been reached to open the exhibition to the public, and the attendance in the early part of the week suggests that this policy will be amply justified. The exhibition was opened on Monday last, the 8th inst., at the Central Hall, Westminster, and closes to-morrow. The exhibits are classified under two sections, comprising, respectively, those already on the market, and those which have not yet reached that stage. Prizes are being awarded amongst the exhibitors in the latter class, the awards being given for the best inventions in various sub-sections. Amongst these may be mentioned domestic and labour-saving devices, housing, and wireless. Two special prizes will be awarded for the best inventions exhibited by a woman.

The exhibition is in no sense intended to be confined to developments in engineering, and, in fact, covers a much wider field, but engineers able to spare the time to pay a visit to the exhibition could find quite a number of purely mechanical devices worthy of careful study. Our space does not permit of more than a brief reference to the actual exhibits, but amongst these mention ought certainly to be made of a new form of hacksaw frame introduced by Mr. A. Collier, of 453, Brixton-road, S.W. 1, under the name of the "Shetack" saw. In this tool the frame is a triangular sheet of tempered steel, which is thin enough to pass through the slot made by the saw. The frame is backed along the top edge only, in a similar manner to a tenon saw, but the hacksaw differs from the latter in that the teeth are formed on a renewable blade in the usual way, and also in that this blade is set at an angle to, instead of being parallel with, the back. As a result of this construction, the frame follows the saw blade through the work without fouling, and cuts of indefinite length can be made. The construction offers another important advantage, which should prove of especial value in cutting thin plates or tubes, in that the sheet steel frame forms a guide and prevents the saw from being twisted in the slot, which is a frequent cause of fracture in the class of work referred to.

An interesting variable-speed electric motor is shown by Mr. P. T. King, of 15 and 17, Manchester-street, Luton. In this machine, both the armature and field magnets rotate, the current for the latter being fed on by special slip rings mounted on the field frame. Either the armature or the frame can be braked as desired, and the resulting speed of the armature shaft will depend on the braking torque applied to the one part or the other, the relative speed between the armature and field magnets always remaining constant. The arrangement has obvious objections for heavy work, but should prove useful in a number of cases where a wide speed range, combined with infinitely variable control, is required with small powers. A number of inventions applicable to motor vehicles are shown on the various stands, amongst which a useful two-purpose body was noticeable. This is exhibited by "Two-in-one" (S. C.) Motor Bodies, of 39, Victoria-street, S.W. 1, and consists of a four or five-seater passenger body which can be fitted without modification on to a number of standard chassis. To convert the body from the passenger to the van type, the rear seat can be stowed in the rear of the driver's seat panel, the rear squab reversed, and the trimming housed in the tail-board, when the floor boards hinge up and form a protection for the side trimming. When these operations are completed, the rear compartment has a length of 4 ft. 6 in., a width of 3 ft. 8 in., and a height from floor to waist of 2 ft. It is completely lined with galvanised sheeting, and this not only forms an efficient protection to the concealed trimming, but is very readily washed down. The change over can be completed in two or three minutes, and only requires a single key of the carriage-door type.

NEWARK SEWERAGE SCHEME.—Recently Dr. Calvert, of the Ministry of Health, held an inquiry at Newark into the Corporation's application for permission to borrow 2,726*l.* to enable the completion of their sewerage and sewage-disposal works to be carried out. Alterations to Newark's sewerage scheme and the installation of a sewage-disposal works on a new system of activated sludge have already been undertaken at a total cost of 59,686*l.* The consulting engineers are Messrs. W. H. Radford and Son, of Nottingham.

EVAPORATION LOSSES FROM OIL TANKS OF DIFFERENT COLOURS.

EXPERIMENTS conducted in the laboratory of the United States Bureau of Mines having clearly demonstrated that the colour of the painted surface of an oil container had a material influence on the rate of evaporation of the contents, tests on a large scale, under actual working conditions, were carried out. Four storage tanks of 50,000 barrels capacity were utilised for the purpose, and an account of the investigation is recorded in Report, Serial No. 2,677, drawn up by Mr. Ludwig Schmidt and issued by the United States Bureau of Mines. The roofing material of the tanks consisted of wood covered with galvanised iron sheets, and every effort was made to maintain them vapour-tight during the experiment. The most satisfactory results in the laboratory tests having been obtained from aluminium paint, one of the tanks and its roof was given a coating of this material; the other three containers and their roofs were painted black, red, and grey, respectively.

The tanks were filled with crude oil containing approximately 29 per cent. of the lighter fractions, gasoline and naphtha. The duration of the experiment was prolonged for the period of one year, from January to January, in order to obtain average weather conditions and to make the test as exhaustive and complete as possible. The volume of oil contained in the tanks was estimated every month and samples for inspection and analysis were taken at regular intervals. At the conclusion of the experiment, the yearly evaporation loss, measured in barrels of oil, amounted to 649 in the case of the tank painted black and 609 in the case of the red tank. The figures for the tanks coated with grey and aluminium paint were 547 and 447, respectively. These results indicate that evaporation losses are lessened considerably by coating the exposed surface of an oil tank with a paint which tends to reflect radiated heat waves.

Other factors besides that of colour have a bearing upon the problem, however, and the two most important have reference to the protective value of the paint, and to its cost. With regard to the former, the investigation showed that the weathering properties of light-coloured paint were quite equal to those of dark paint; there should, therefore, be no marked difference in the protective value of the two materials. The question of costs is always an involved one, but taking into account the distinct advantages gained, it would appear that any additional expense incurred by the use of light pigments for the painting of tanks is more than compensated for by the corresponding reduction in oil wastage.

TENDERS.—The Department of Overseas Trade, of 35, Old Queen-street, London, S.W. 1, announces that the Electricity Department, City of Cape Town, invite tenders, to be presented not later than July 22, 1925, for the supply and delivery of pumping equipment for storm water and sewage-disposal works now under construction. Two motor-driven pumps, piping, switchgear, and a hand-operated travelling and traversing overhead crane are required in connection with this undertaking. Full particulars of the requirements may be obtained from the Department of Overseas Trade.

TURBINE STEAMER "GLEN SANNOX."—Recently completed by Messrs. William Denny and Brothers, Limited, of Dumbarton, for the London, Midland and Scottish Railway Company, the turbine steamer Glen Sannox carried out her official trials on the River Clyde. The vessel is intended for service on the Ardrossan-Arran route. The principal test required to be fulfilled was the performance of a double run between the Clock and Cumbrae lights at a mean speed of 20·75 knots. The actual mean speed the ship attained was 21·15 knots, the machinery working to the satisfaction of the owner's representatives. Compared with earlier vessels of the same class greatly augmented astern power is provided.

CONTRACTS.—Messrs. Daniel Adamson and Co., Limited, engineers and boilermakers, of Dukinfield, Manchester, have secured contracts for the supply, delivery and erection of sewage lifting plants for service at Bamford, Derbyshire, at Billington, near Macclesfield, at Chapel-en-le-Frith, and at Greasborough.—The Thorne Rural District Council have accepted the offer made by Messrs. A. Waddington and Son, of Sheffield, to carry out, at a cost of 11,250*l.*, the construction of the first section of the sewerage scheme at Thorne and the immediate vicinity.—Messrs. International Combustion, Limited, of Africa House, Kingsway, London, W.C. 2, announce that their associated company, Combustion Engineering, Limited, have secured a contract for the largest Lopulco pulverised fuel plant yet designed in the British Empire from the St. Maurice Lumber Company, through the latter's consulting engineers, Messrs. McLellan and Junkersfeldt. Lopulco feeders and burners, horizontal and rear wall water screens, Murray fire-side walls, five 6-ton Raymond mills, five driers and five air-heaters, with forced and induced-draught fan equipment, will serve four Babcock and Wilcox boilers, each having 10,470 sq. ft. of heating surface and working at a pressure of 130 lb. per square inch.

BOOKS RECEIVED.

A Text-Book of Wireless Telegraphy and Telephony. By W. GREENWOOD, B.Sc. London: University Tutorial Press, Limited. [Price 5*s.* 6*d.* net.]

Power Plant Machinery. Vol. II. *Details and Accessories.* By WALTER H. JAMES and MYSON W. DOLE. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Limited. [Price 15*s.* net.]

Kent's Mechanical Engineers' Handbook. Vols. I and II. By the late WILLIAM KENT. Tenth edition rewritten by ROBERT THURSTON KENT, M.E. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Limited. [Price 40*s.* net.]

Alignment Charts for the Engineer. Part I. *Air and Steam.* By Stanley R. CUMMINGS and JOSEPH LIPKA, Ph.D. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Limited. [Price 11*s.* net.]

Electricity and the Structure of Matter. By L. SOUTHERNS, M.A., B.Sc. London: Oxford University Press. [Price 2*s.* 6*d.* net.]

Manuel Pratique des Poseurs de Voies de Chemin de Fer. By Henri Salin. Paris: Dunod. [Price 15 francs.]

The Internal-Combustion Locomotive. By J. W. HOBSON. Paper read before the North-East Coast Institution of Engineers and Shipbuilders, Newcastle-upon-Tyne. February 13, 1925. Newcastle-upon-Tyne: Offices of the Institution. London: E. and F. N. Spon, Limited. [Price 4*s.* 6*d.*]

United States Bureau of Standards. Technologic Papers. No. 279, *Testing of Fire-Clay Bricks with special reference to their use in Coal-Fired Boiler Settings.* By R. F. GELLER. [Price 20 cents.] No. 282, *Technology of Cotton Machinery.* Part I. *Calculations on Pickers.* By A. A. Mercier. [Price 10 cents.] Washington: Government Printing Office.

A Short Account of the Nile and its Basin. By H. E. HURST, M.A., D.Sc. Cairo: International Congress of Geography.

Études Techniques du Groupement des Houillères victimes de l'invasion. Vol. I. Destruction, Déblaiement, Dénoyage. Issued by the Comité Central des Houillères de France. Paris: Gauthier-Villars et Cie. [Price 40 francs.]

The Railway Year-Book, 1925. London: The *Railway Magazine.* [Price 5*s.* net.]

Department of Scientific and Industrial Research. Fuel Research Board. Technical Paper No. 11, *The Microstructure of a Coal Seam.* By J. Lomax, F.G.S. London: His Majesty's Stationery Office. [Price 4*s.* 6*d.* net.]

Schwindspannungen in Trägern aus Eisenbeton. By LEOPOLD HERZKA. Leipzig: Alfred Kroner. [Price 5.50 marks.]

Die Vereinfachte Berechnung biegsamer Platten. By Dr. ING H. MARCUS. Berlin: Julius Springer. [Price 5·10 gold marks.]

Refrigeration in the Chemical Industry. By G. W. DANIELS, M.Eng., Wh. Ex. London: A. J. Rayment.

The Engineering Index, 1924. New York: American Society of Mechanical Engineers. [Price 7 dollars.]

Lewis Institute. Structural Materials Research Laboratory. Bulletin No. 9. *Quantities of Materials for Concrete.* By DUFF A. ABRAMS and STANTON WALKER. Chicago: Structural Materials Research Laboratory.

Die Festigkeitslehre. By R. LAUENSTEIN. Sixteenth edition. Leipzig: Alfred Kroner. [Price 5 marks.]

Der Eisenbeton; seine Berechnung und Gestaltung. By RUDOLF SALIGER. Fifth edition revised. Leipzig: Alfred Kroner. [Price 24 marks.]

PERSONAL.—The retirement is announced, for reasons of health, of Mr. Thomas Fender, a special director of Messrs. Vickers Limited. Mr. Fender was educated at the Elswick Works School and Institute, afterwards serving his apprenticeship with Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, at their Elswick Works. In due course he was promoted to be foreman in the Gun Department, and later he was appointed to the Machine Inspection Department. In 1901 Mr. Fender left Elswick and joined the staff of Messrs. Vickers Limited, at Barrow-in-Furness, with the object of introducing the premium bonus system of payment by results, an achievement which he successfully accomplished. Appointed works superintendent at Barrow in 1910, his valuable services during the period preceding 1919 were recognised by his being created a special director of the company. This position he will retain for a further two years.—The Consolidated Pneumatic Tool Company Limited, of Egyptian House, 170, Piccadilly, London, W. 1, have opened an office and service depot at 2, Harrington-street, Sydney, Australia.—Mr. F. L. Warren, consulting engineer and naval architect, has removed from 155 to 139, Fenchurch-street, London, E.C. 3.—Mr. David Baker, consulting metallurgical engineer, who for the last twelve years has been engaged in the establishment of the iron and steel department of the Broken Hill Proprietary Company, Limited, at Newcastle, Australia, has now re-opened an office at 1011, Chestnut-street, Philadelphia, Pa., U.S.A.—Mr. S. Nichols has been appointed manager of the Middlesbrough office of the British Thomson-Houston Company, Limited.—Messrs. Alfred Herbert, Limited, of Coventry, have terminated their agreement with the J. M. Carpenter Tap and Die Company, of Pawtucket, Rhode Island, U.S.A., and have entered into an agreement for the representation of the Morse Twist Drill and Machine Company, of New Bedford, Mass., U.S.A. Messrs. Alfred Herbert, Limited, are now agents for all Morse products, such as drills, reamers, sockets, &c.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Hull Coal Traffic.—Though there are signs of steady improvement in business with some of the foreign markets, the main tendency of South Yorkshire's coal trade continues to be downwards. Compared with the corresponding month last year, the total received at Hull, during May represented a decrease of over 100,000 tons. Added to the fall for the preceding four months, this showed a total shrinkage of close on 200,000 tons—actually 197,000 tons. Exports to France, Germany and Holland were again on a much smaller scale. Germany only took 32,237 tons for the five months against over four times as much, namely, 148,997 tons, during January to May (inclusive) of 1924, while shipments to France fell from a quarter of a million tons to 157,000 for these respective periods. Business with Holland was not much more than half the total for last year, and sales to Belgium were down 30 per cent. On the other hand, increased tonnages were taken by South America, Denmark, Italy, Iceland, Latvia, Norway and Spain. One of the most interesting features was the recovery of trade with Sweden, one of South Yorkshire's biggest customers. The total sent last month increased by 10,000 tons to 42,000, as compared with May, 1924, bringing this year's total to 151,000 tons, or less than 4,000 tons short of the total for the first five months of last year.

Iron and Steel.—Following on the receipt of the Australian battleship orders comes the welcome news of the placing of extensive contracts for steel rails in the South Yorkshire district. These are from the London, Midland and Scottish Railway. Messrs. Steel, Peach and Tozer and Messrs. Cammell Laird and Co., both of Sheffield, are each to supply 10,000 tons, and Messrs. Samuel Fox and Co., of Stocksbridge, 6,000 tons. Industrial Sheffield also has a special interest in the fact that the Workington Iron and Steel Company are to supply a further 10,000 tons to the same railway. These orders will afford some relief from a situation that had become very trying, and that threatened to call for a further restriction of output and release of operatives. The position affecting mild steel production remains, however, very unsatisfactory, and is mainly responsible for the marked fall in the gross output of the district. The latest returns show a shrinkage of 17,000 tons for the Sheffield area during April last, as compared with the previous month, and of 22,000 tons as compared with April last year. Efforts are being made to stimulate buying by the offer of lower prices, ranging up to a reduction of 10*s.* per ton, but, as in scrap and pig-iron, there is scarcely any movement beyond hand-to-mouth purchases. The shrinkage in the demand for machine tools is one of the least satisfactory features of the position in the engineering trades, Oil-fired cooking apparatus is being made locally for the three British battleships under construction. Sheffield Corporation have placed orders locally for truck frames, trolley wheels, controllers and switch points in connection with their tramways undertaking; for structural steelwork, fuses and fittings for their electrical undertaking; and for hydrants and iron castings for their water department. On the whole, toolmakers are fairly well employed, substantial quantities of shovels, spades, files, rasps, axes and carpenters' tools being under order for shipment.

South-Yorkshire Coal Trade.—Further reductions in house-coal prices were expected owing to seasonal contraction in buying. This contraction is perhaps rather more marked than usual, and has left collieries and depots short of orders. Best house and best brights have each declined another shilling per ton. Export weakness, coupled with the sluggish character of the home industrial demand, has reacted against business in steam fuel, both Yorkshire and Derbyshire hards having been marked down 9*d.* per ton. The position, from the standpoint of pit top prices, is otherwise unchanged, cobbles, slacks, and coke all representing a sub-normal market. Quotations:—Best hand-picked branch, 30*s.*, to 33*s.*; Barnsley best silkstone, 26*s.* to 27*s.*; Derbyshire best brights, 23*s.* to 26*s.*; Derbyshire best house, 21*s.* to 23*s.*; Derbyshire best large nuts, 17*s.* 6*d.* to 20*s.*; Derbyshire best small nuts, 12*s.* to 14*s.*; Yorkshire hards, 17*s.* 6*d.* to 21*s.*; Derbyshire hards, 17*s.* 6d. to 21*s.*; rough slacks, 10*s.* to 12*s.* 6*d.*; nutty slacks 8*s.* 6*d.* to 10*s.*; smalls, 3*s.* 6*d.* to 5*s.* 6*d.*

LAUNCH OF THE S.S. "PLATON."—Recently Messrs. William Gray and Co., Limited, of Pallion, Sunderland, launched, from their Wear Shipyard, the steamer Platon which is being constructed for the Compagnie de Navigation d'Orbigny, of Paris. The vessel is of the shelter-deck type with forecastle, and has an overall length of 412 ft. 6 in., an extreme breadth of 53 ft. and a moulded depth, to the upper deck, of 27 ft. 6 in. The gross tonnage is 4,610, and the deadweight 8,100 tons. A steel centre-line bulkhead is fitted fore and aft of all holds, the latter being primarily designed for the carriage of grain, though the ship is intended for general trading purposes. Triple-expansion engines, having cylinders 26 in., 43 in. and 71 in. in diameter, with a stroke of 48 in., together with three multitubular boilers, working at a pressure of 180 lb. per square inch, are being installed by the builders. The auxiliary machinery will include pumps, evaporator, a direct-current heater, and a combined drain and scum tank, all of the firm's C.M.E.W. type. Eleven winches and ten derricks are fitted, each of the latter being capable of handling a 5-ton load. The steering gear is placed at the after end of the engine casing on the shelter deck, and is operated by controlled shafting from the navigating bridge. The vessel is being built to the requirements of the Special Survey of Lloyd's Register and also of the French law.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Conditions in the Cleveland pig-iron trade are causing considerable anxiety. Whilst the statistical situation is a strong one, stock being low, and production little, if anything, in excess of the very moderate current needs, a distinctly easy feeling prevails, and customers are extremely cautious in their dealings, being very disinclined to negotiate for forward supplies. Values still tend downward. No. 1 is now on sale at 79*s.*; No. 3 g.m.b. is 74*s.*; No. 4 foundry, 73*s.*; and No. 4 forge, 72*s.*

Hematite.—East Coast hematite is plentiful. Makers have rather heavy stocks that they are keen to liquidate, and values show further downward movement. A few sales to the Sheffield district and to local and other home customers have been put through, but inquiry from abroad is meagre. Nos. 1, 2 and 3 are 79*s.*, and No. 1 is quoted 79*s.* 6*d.*

Foreign Ore.—Transactions in imported ore are little heard of. Sellers still base market rates on best rubio at 22*s.* c.i.f. Tees, but are prepared to give favourable consideration to offers on lower terms.

Blastfurnace Coke.—Durham blastfurnace coke is in very ample supply, and demand is only moderate. Local consumers claim they can readily cover their needs at round about 21*s.* 6*d.* for good average qualities delivered.

Manufactured Iron and Steel.—The various branches of manufactured iron and steel present few new features of moment. Most descriptions of material are difficult to dispose of, but demand for steel rails and for constructional steel shows some improvement; whilst sheet producers report continued good inquiries. Common iron bars are 11*l.* 12*s.* 6*d.*; iron rivets, 13*l.* 10*s.*; packing (parallel), 8*l.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 7*l.* 10*s.*; steel billets (medium), 8*l.*; steel billets (hard), 9*l.*; steel boiler plates, 12*l.* 10*s.*; steel ship, bridge and tank plates, 8*l.* 10*s.*; steel angles, 8*l.* 5*s.*; steel rivets, 13*l.*; steel joists, 8*l.* 5*s.*; heavy sections of steel rails, 8*l.* 10*s.*; black sheet (No. 24 gauge), 11*l.* 5*s.*; and galvanised corrugated sheets (No. 24 gauge), 16*l.* 10*s.*

THE OIL-SHALE INDUSTRY OF ESTONIA.—Three years ago Mr. E. H. Cunningham-Craig read a paper on the geology of the Estonian oil shales before the Institution of Petroleum Technologists, upon which we commented on page 624 of our issue of May 19, 1922. Recently Mr. P. N. Kogerman, M.Sc., reported on "the Present Status of the Oil-Shale Industry of Estonia," before the same Institution. Exploitation of the fields by the Russian Fuel Commission was started in 1916. The Estonian State now works the mines at Kohtla (open-cut mining) and Kukruse (from which the local name Kukersite for the shale is derived); there is, further, an Estonian Shale Development Syndicate with British capital at Vanamöisa, where fusion stills are used, and over twenty prospecting permits have been granted. The total shale production up to 1923 was about 500,000 tons. The shales are very rich, but contain 1 per cent. or more of sulphur, and are directly used as fuel (much cheaper than coal and wood for railway engines), for lime kilning, and chiefly for Portland cement burning; the ash has the properties of a Roman cement. Gas is also produced from the shale. The oil distillation is considered most promising, but Mr. Kogerman pointed out that much of the previous information published was unreliable. Three experimental plants were now working on a large scale, at Kohtla and Püssi (Pintsch retorts) and in the British works; the former continuous retorts were vertical, 2 m. in diameter and 5 m. high, for throughputs of 8 tons per day. The oil contained 1 per cent. of sulphur and served at present mainly as fuel; chemical refining was not applied. So far the oil-shale mines supplied mainly the home market.

PERMANENT TRADE EXHIBITION AT NEW ORLEANS, U.S.A.—It is announced that under the auspices of the Government of the United States, a permanent International Trade Exhibition will be instituted at New Orleans, Louisiana, on September 15, 1925. The object of this Exhibition is to permit of a continuous display of samples of manufactured and raw products of the United States and of all other countries participating in the venture. President Coolidge has issued a formal invitation to foreign peoples to take part. While the Exhibition is designed to include all branches of industry, the organisers are especially desirous of securing comprehensive ranges of exhibits coming under the headings of machinery, radio and electrical apparatus, automobiles, agricultural implements, vehicles, boats, and agricultural, textile, chemical and glass products. The price of space is approximately 12*s.* 6*d.* a sq. ft. per annum, and the minimum space which will be sold is 150 sq. ft. The charge includes heating, lighting, and telephone service and a limited amount of typewriting assistance, together with the use of translators and interpreters. New Orleans is the largest port in the southern United States, with a population of over 380,000, and is situated on the east bank of the Mississippi River. The exports and imports handled at this centre in 1922 amounted to some 10 million tons of goods, valued at 100,000,000*l.* British manufacturers and traders who are interested in the possibilities of this market, and who may wish to participate in the Exhibition, should consult a pamphlet which contains further information on the subject, on view at the Department of Overseas Trade, 2, Queen Anne's-gate Buildings, London, S.W.1.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Conditions have been dull and uninteresting in the Scottish steel trade during the past week. The demand for all classes of material for shipbuilding and general purposes has been poor, and buyers continue to order only the minimum quantities required. The home inquiry is not encouraging and export business is of a very limited description. Since prices were freed there has been exceedingly keen local competition for anything on offer, with the result that less Continental material has been in evidence. The outlook for the industry is not bright, and the stoppage for the annual holidays in five weeks' time will be a welcome break to the various managements. In the black sheet trade conditions have not varied over the week. There is a fair amount of work on hand with the majority of the makers of galvanised sheets exceedingly well off as regards orders on the books. The export demand is keeping up very well indeed. Selling prices are mostly a matter of arrangement, but the following may be taken as the current market quotations:—Boiler plates, 12*l.* 10*s.* per ton; ship plates, 8*l.* 12*s.* 6*d.* per ton; sections, 8*l.* 2*s.* 6*d.* per ton; and sheets, $\frac{7}{16}$ to $\frac{1}{4}$ in., 10*l.* 5*s.* per ton, all delivered Glasgow.

Malleable Iron Trade.—Little movement has taken place in the malleable iron trade of the West of Scotland over the week. Makers are very scarce of tonnage and the orders coming in are usually small and quickly run off. Similar conditions are general in the steel re-rolling departments at present. The price of "Crown" bars is 11*l.* 12*s.* 6*d.* per ton delivered Glasgow stations.

Scottish Pig-Iron Trade.—The pig-iron trade of Scotland continues exceedingly quiet and is passing through serious times. The present day production has been reduced to a minimum and even that suffices to more than meet the demand. Few inquiries are being received. Prices tend downwards and to-day's quotations are as follows:—Hematite, 4*l.* 7*s.* 6*d.* per ton, delivered at the steel works; foundry iron No. 1 4*l.* 7*s.* 6*d.* per ton, and No. 3, 4*l.* 5*s.* per ton, both on trucks at maker's yards.

Scottish Pig-Iron Shipments.—For the week ending last Saturday, June 6, the amount of Scottish pig-iron shipped from Glasgow Harbour was 608 tons. Of that total 484 tons went foreign and 124 tons coastwise. For the corresponding week of last year the figures were 523 tons overseas and 40 tons coastwise, making a total shipment of 563 tons.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Exports of coal as cargo foreign from South Wales in May totalled 2,024,600 tons, which was 107,000 tons more than the quantity despatched in April. It was, however, 250,000 tons below the volume of the trade dealt with in the corresponding month of a year ago. Shipments from Cardiff in the past month totalled 1,204,300 tons, from Newport 394,100 tons, from Swansea 268,300 tons, from Port Talbot 142,600 tons, and from Llanelly 15,300 tons. Shipments to France amounted to 613,200 tons or 311,000 tons less than in May of last year while Italy took 252,900 tons, a reduction of 10,300 tons. On the other hand, exports to South America were increased by 12,000 tons to 345,500 tons and to Canada by 64,700 tons to 91,200 tons. Spain took 132,100 tons, Portugal 98,100 tons, Greece 42,500 tons, British coaling depots 216,700 tons, Belgium 26,100 tons, Holland 7,300 tons, Germany 1,700 tons, the Irish Free State 43,800 tons, and unclassified countries 153,200 tons. Meanwhile, the demand at present is extremely limited and prices generally display a weaker tendency. Quotations on the whole are unaltered, but buyers able to take early delivery can secure practically any description of coal at concessions of 3*d.* to 6*d.*, the amount varying according to individual circumstances. In a few isolated cases colliery salesmen are comfortably situated for the present and able to adhere to quotations, but with little new business coming in and buyers following a waiting policy the majority of collieries are prepared to accept lower prices for firm business. Best Admiralty large is round 26*s.* with seconds from 24*s.* 6*d.* to 25*s.* 6*d.*, and dry large from 23*s.* 6*d.* to 25*s.* 6*d.*, while Monmouthshires rule from 22*s.* 6*d.* to 24*s.* 6*d.* Smalls, too, are irregular and weak at 10*s.* to 15*s.*, according to quality. Shipments of coal in the past week totalled 348,160 tons, of which 19,650 tons went to Argentina, 24,500 tons to Egypt, 118,530 tons to France, 34,950 tons to Italy, and 19,370 tons to Spain.

Iron and Steel.—Exports of iron and steel goods in the past week totalled only 8,746 tons, compared with 10,641 tons in the previous week. Shipments of tinplates and terneplates totalled 3,908 tons against 5,770 tons; blackplates and sheets, 755 tons against 1,860 tons; galvanised sheets, 1,303 tons against 2,594 tons; and other iron and steel goods, 2,780 tons against 417 tons. Business in Welsh tinplates continues steady but costs approximate prices and in some cases higher. The rise in tin has added a 1*d.* to the basis box, while the fall in prices since the stabilisation scheme fell through represents a reduction of about 10 per cent. Works now are not disposed to offer supplies at below 20*s.* f.o.b. at the works port, though a few parcels have changed hands at a little less. An Australian order has been placed for 10,000 boxes, but this represents less than a fifth of a day's production from the Welsh works.

NOTICES OF MEETINGS.

THE ROYAL SOCIETY OF ARTS.—To-day at 4.30 p.m., at John-street, Adelphi, W.C. 2. Indian Section, "The Heart of Asia and the Roof of the World," by Brigadier-General Sir Percy M. Sykes, K.C.I.E., C.M.G. Thursday, June 18, at 4.30 p.m. Dominions and Colonies Section. "Some African Problems," by Hon. W. Ormsby-Gore, M.P.

THE PHYSICAL SOCIETY OF LONDON.—To-day at 5 p.m., at the Imperial College of Science, South Kensington, S.W. 7. "Our Mass and Energy," by Mr. G. Temple, Ph.D. "The Characteristic Curves of Liquid Jets," by Mr. E. Tyler, M.Sc., and Mr. E. G. Richardson, M.Sc., Demonstrations of "Some Experiments to Illustrate the Application of the Shakespeare Katharometer to Physical Research," by Dr. H. L. Daynes. "Some Simple Apparatus for the Estimation of Carbon Dioxide," by Dr. Ezer Griffiths.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—To-day at 9 p.m., at Albemarle-street, W.1. "Faraday as a Chemist," by Sir William Jackson Pope.

THE INSTITUTION OF MINING ENGINEERS.—Summer Meeting, Tuesday June 16, to Thursday, June 18, at the South Wales Institute of Engineers, Park Place, Cardiff. Tuesday, June 16, at 11 a.m. "Petroleum Refining in South Wales," by Sir John Cadman, D.Sc. "The Maximum Efficiency of Heat Engines and the Future of Coal and Steam as Motive Agents," by Dr. J. S. Haldane, F.R.S. "The Shutting Off of Gob-Fires in Gassy Seams." Memorandum by the Gob-Fires Committee of the Institution. "Spontaneous Combustion in the South Wales Coalfield," by Mr. J. Ivon Graham, M.A., M.Sc., and Mr. T. D. Jones, Ph.D., M.Sc. "The Principles and Operation of the Mines (Working Facilities and Support) Act, 1923, Part I, by Mr. John H. Cockburn. At 3 p.m., Visit the Tin Plate Works of the Melingriffith Co., Limited, Whitchurch. Wednesday June 17, at 8.45 a.m., Visit to the Llandarcy Oil Refinery Works of the Anglo-Persian Oil Co., Limited. At 7 p.m., Institution Dinner at the Park Hotel, Cardiff. Thursday, June 18, at 9 a.m. Visit to Powell Duffryn Collieries.

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—Annual General Meeting. Wednesday, June 17, to Saturday, June 20, at Harrogate. Wednesday, June 17, at 10 a.m., in the Royal Hall. Presidential Address by Mr. Frank Massie, M.Inst.C.E., F.S.I. At 2.30 p.m., in the Royal Spa Concert Room. Address by Sir Henry P. Maybury, K.C.M.G. Discussion of Papers. "Harrogate and its Municipal Undertakings," by Mr. C. E. Rivers. "Assistance from National Funds for Sewerage Works and Water Supply in Rural Districts," by Mr. A. J. Redfern. At 8.15 p.m., Reception by the Mayor and Mayoress of Harrogate. Thursday, June 18, at 9.30 a.m. Visit to Harrogate Reservoir and Fountain's Abbey. At 7 p.m., Annual Dinner at the Hotel Majestic. Friday, June 19, at 10.30 a.m. in the Royal Spa Concert Room. Address by Mr. G. L. Pepler on "Town Planning for Rural or small Urban Districts." "Sewage Works for Smaller Districts," by Mr. J. D. Watson, M.Inst.C.E. At 1 p.m., Visit to the Royal Baths. At 2.30 p.m., "The Smaller Boroughs: Their National and Economical Administration Value," by Mr. J. W. Hipwood, A.M.Inst.C.E. "Municipal Undertakings in Small Boroughs," by Mr. Gilbert, A. Ballard, A.M.Inst.C.E. At 4 p.m., Visit to the Harrogate Central Depot. Saturday, June 20, at 9.15 a.m., Visit to Harrogate Southern Outfall and Sewage Disposal Works and Knaresborough.

THE RAILWAY YEAR BOOK, 1925.—Once again a feature of *The Railway Year Book*, issued by the Railway Publishing Company, Limited, of 33, Tothill-street, Westminster, London, S.W.1, at a price of 5*s.* net, is rearrangement and essential revision, with the addition of new material as necessitated by further developments in railway grouping. This time, however, these changes are associated with the Irish section. Under the Irish Railways Act of 1924 practically all lines in the Irish Free State, except the Great Northern, are in course of amalgamation and absorption into the new Great Southern Railways. In view of this essential change, an article is included in the book dealing with the new system, and setting forth the directorate of the Great Southern Railways Company and its chief officers, together with historical and other information. To allow for the fact that the Great Southern Railway—the name Great Southern Railways has applied only since January 1 of this year—as first constituted did not include the Dublin and South Eastern Railway, statistical information is necessarily given on a sectional basis. An analysis of the Irish Free State Railways Act is given. A further feature associated with the Irish section, which also includes detail adjustments and revisions, is a new and specially drawn map of the Great Southern Railways system. In the British section articles relating to the various railways have been extensively revised and in many cases amplified. Opportunity has been taken to set forth the capital of the respective companies in greater detail than heretofore. New maps have been prepared for the article dealing with the Southern, Somerset and Dorset Joint, Metropolitan and "Underground" systems. For the first time, in addition to the classified contents, a comprehensive index is included. In the foreign sections, railways in colonies, protectorates, &c., hitherto classified separately, have now been placed in sub-classes according to their geographical location. The "Who's Who" section, which has proved of exceptional usefulness, has been entirely revised in view of the numerous changes amongst the officials which have occurred during the past year.

FOUR-SPINDLE PLANO-MILLING MACHINE FOR DIESEL ENGINE BEDS.

CONSTRUCTED BY MESSRS. KENDALL AND GENT (1920), LIMITED, ENGINEERS, GORTON, MANCHESTER.

(*For Description, see Page* 733.)

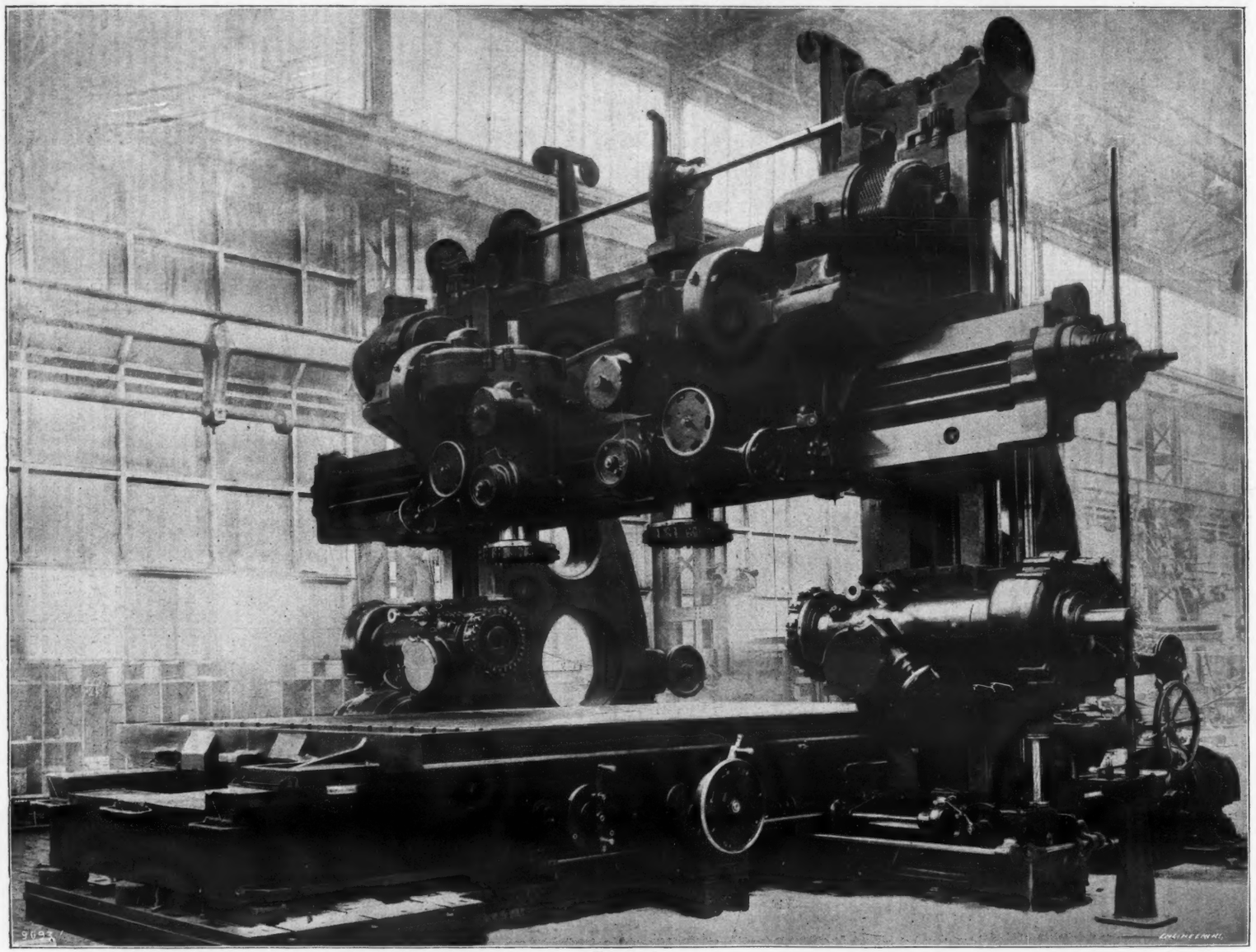


FIG. 2.

THE GANDY BRIDGE ACROSS TAMPA BAY, FLORIDA, U.S.A.

(*For Description, see Page* 729.)

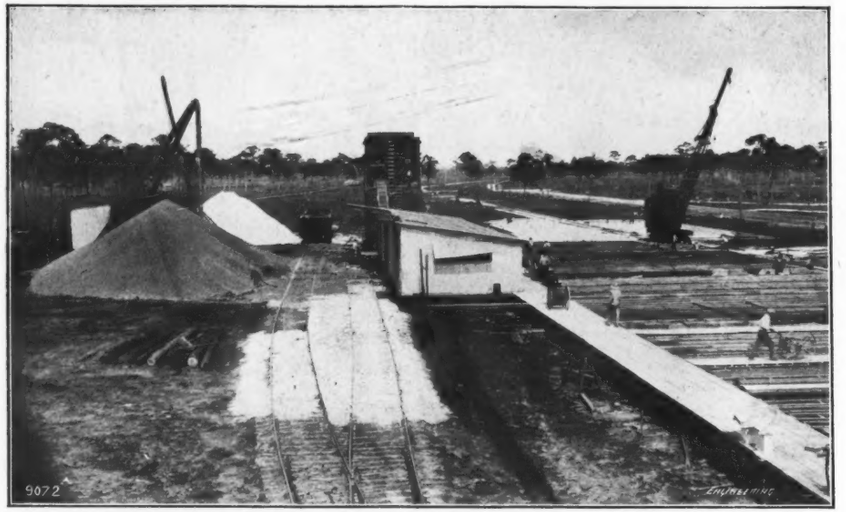


FIG. 3. CONCRETE PILE PLANT.

FIG. 4. BENDING PLANT FOR CONCRETE PILE REINFORCEMENT.

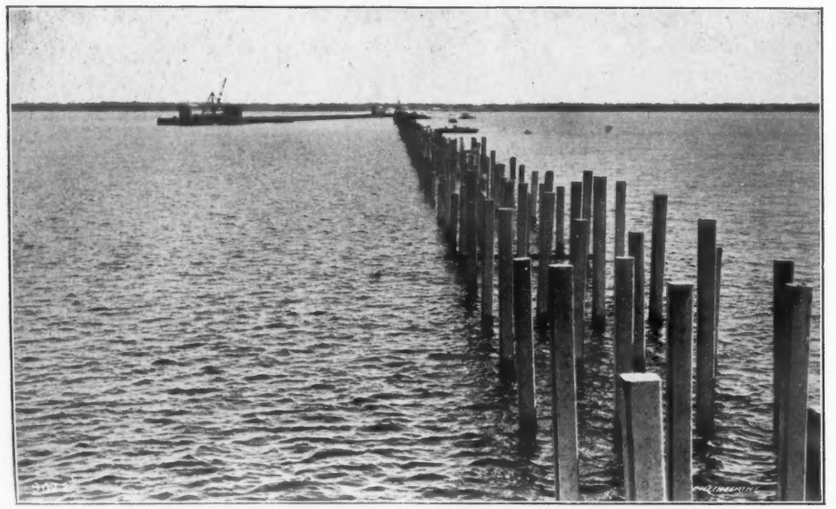


FIG. 5. CONCRETE PILES DRIVEN IN POSITION

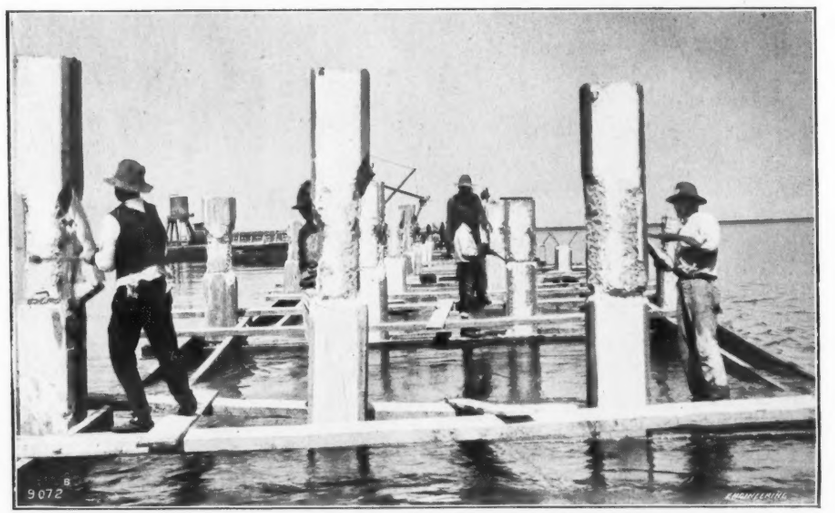


FIG. 6. CONCRETE PILES BEING TRIMMED TO LENGTH.

Fig. 5. Concrete Piles Driven in Position

Fig. 6. Concrete Piles being Trimmed to Length.

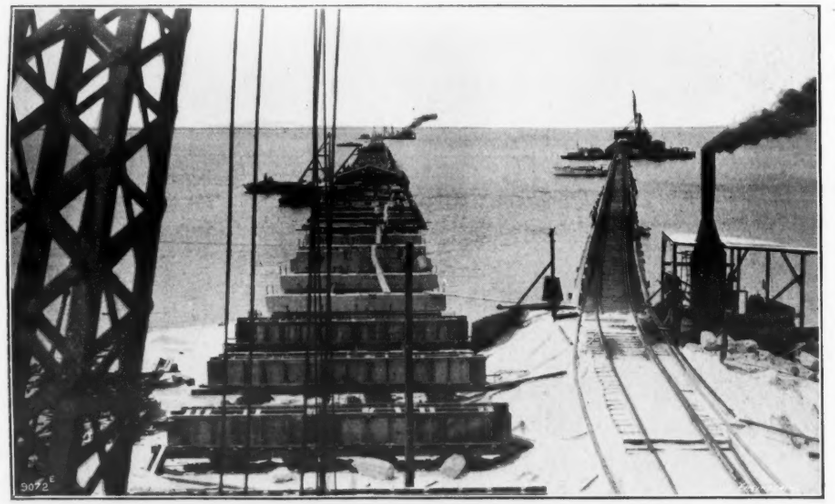


Fig. 7. Pile Caps and Shuttering in Place.

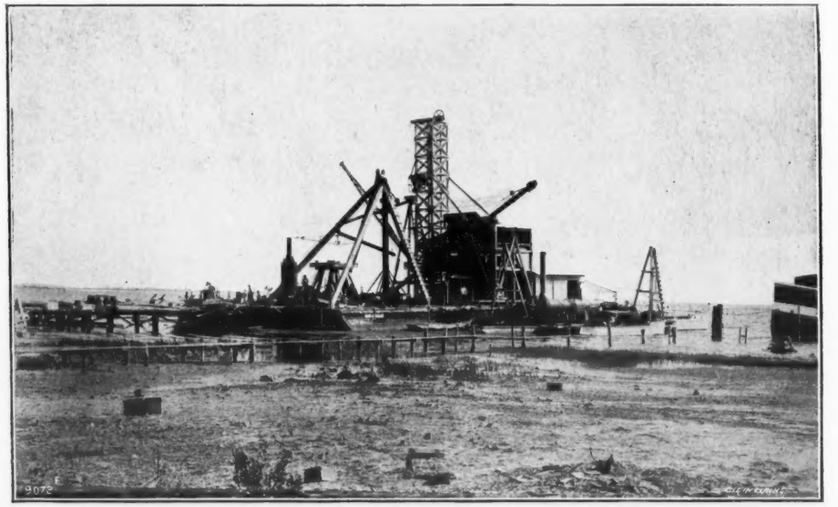


Fig. 8. Floating Concrete Plant.

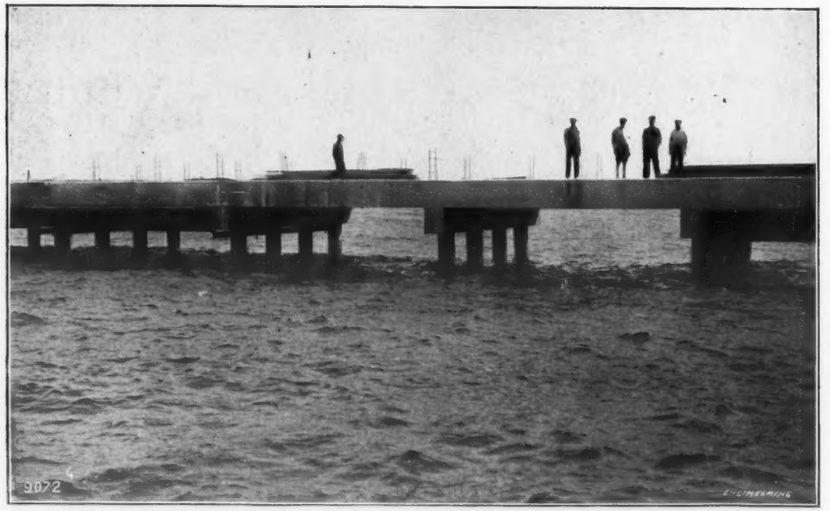


Fig. 9. Portion of Bridge with Beams and Deck Slabs in Place.

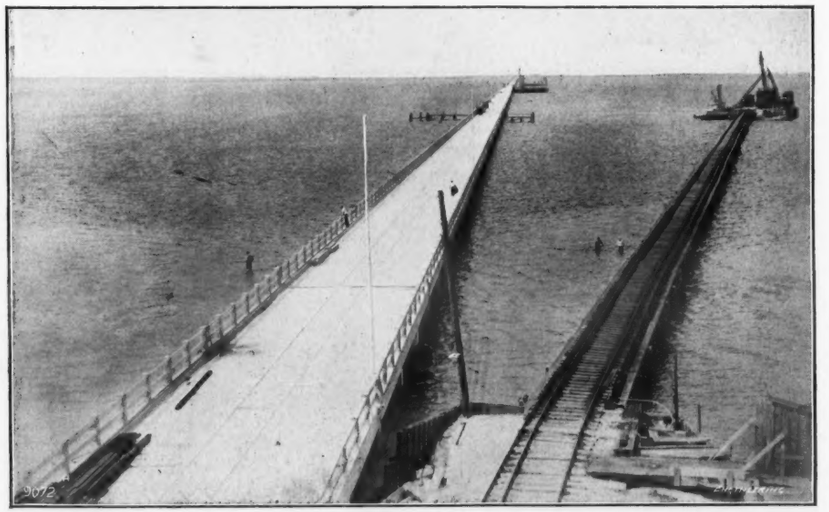


Fig. 10. East End of the Completed Bridge.

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C.2.

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TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received 10 days previous to the day of publication.

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UNITED STATES: For Subscription, New York: W. H. Wiley, 440, Fourth Avenue. For Advertisements: J. S. Allan, 30, Church Street, New York.

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Two - Page Plate. — THE GANDY BRIDGE ACROSS TAMPA BAY, FLORIDA, U.S.A.

ENGINEERING.

FRIDAY, JUNE 12, 1925.

RIVAL METHODS OF SHIP PROPULSION.

IN a multitude of counsellors there may perchance be wisdom, but there is certainly confusion, so that the plain man perplexed by opposing opinions is prone to pursue the prudent policy of Mr. Pickwick at Eatonswill, and to join in the shouts of the largest mob. There are, in fact, fashions in engineering, as well as in feminine modes. The building of the Forth Bridge set every structural engineer talking of cantilevers, with the result that a number of bridges were erected on this system which might better have been built to other plans. The successful construction of the City and South London Tube similarly led to the unnecessary use of shields for other tunnels, and there is a distinct possibility that the great attention now being paid to the internal-combustion marine engine, may give rise to the adoption of the type in instances where the superiority really lies with steam. Of course, there are cases in which one or other of the competing systems has such marked advantages, that rivalry is impossible. The steam launch cannot compete with the high-speed motor launch, nor is the internal-combustion engine suitable for cross-channel packets. In the Navy, again, it would have been impossible to drive the Hood with internal-combustion engines, and, in fact, in all vessels requiring very large powers, the internal-combustion engine is as out of place as it is in large land power stations. Moreover in naval service, the "elasticity" of steam has some special advantages. At the battle of the Falkland Islands, it will be remembered that the steam-driven Kent completely beat her trial trip record. This feat was the more remarkable in that the Kent had reciprocating engines, which have less flexibility than the steam turbine.

In the merchant service, there is not the same demand for flexibility, and the low overload capacity of the Diesel engine is here of but minor importance, while its unquestionable superiority in thermal efficiency is a strong argument in favour of its extended use. The question is, however, by no means so simple as is sometimes assumed. In a letter to *The Times* Lord Bearsted, for example, quotes a Birmingham professor as responsible for the statement that "the oil engine will remain the most economical type of heat engine in existence." Such a remark if not attributable to confusion of thought, is at least open to the charge of carelessness of expression. It is by no means established that the internal-combustion marine engine is the most economical of heat engines, and, in fact, Sir Charles Parsons has declared himself ready to guarantee as high an economy with steam as the best-recorded with the marine Diesel engine.

In short, the terms economy and efficiency cannot be regarded as synonymous. In efficiency no heat engine can even begin to compare with an electric motor taking its current from a primary battery. The chemical energy of the "fuel" consumed in the latter can be converted into useful work with less than 5 per cent. of loss, whilst with the Diesel engine, high as its efficiency is, the loss is fully 60 per cent. Nevertheless, although the suggested combination of battery and electric motor is highly efficient, it is by no means economical. The cost of the fuel has to be considered, in addition to the efficiency with which it can be converted into useful energy, and the protagonists of steam maintain that with current prices of Diesel oil and fuel oil, power can be obtained with steam at a cost not greater than if it were generated by Diesel engines.

In a pamphlet recently published, the Parsons' Marine Steam Turbine Company give some further details of the plant which Sir Charles Parsons had apparently in mind when taking part in the recent discussion at the Institution of Naval Architects—a debate, by the by, in which little share was taken by the advocates of the Diesel engine. The proposals of the Parsons' Marine Steam Turbine Company have reference to a 14-knot vessel, engaged on a voyage of 6,000 miles, and fitted with turbines generating 5,000 shaft horse-power.

A steam pressure of 500 lb. per square inch is specified, combined with superheating to 700 deg. F., water-tube boilers being used. Several boiler makers it may be observed, are prepared to guarantee the performance of boilers of this type at the pressure and temperature named. There would be three turbines in series, of which the high pressure is designed to run at 5,000 r.p.m., the intermediate at 3,000, and the low pressure at 1,700 r.p.m. These speeds would be reduced by double-reduction gearing to 90 r.p.m. at the propeller shaft. A total consumption for all purposes of 0·66 lb. of oil per shaft horse-power is guaranteed, and it must be remembered in this connection, that the guarantees of Sir Charles Parsons commonly hold good; a rule which, unfortunately, is not observed by all turbine builders. One notorious Continental firm, for example, is reported to have been 10 per cent. to 14 per cent. worse than its guarantees in the case of one very large plant erected by them since the war. The 0·66 lb. of oil will, it is claimed, cost no more than the 0·45 lb. which would be taken "for all purposes," by a corresponding Diesel engine plant, and, moreover, the steam plant would have the option of using coal, the guarantee for which "for all purposes" is 0·98 lb. per shaft horse-power.

These figures show how far marine engineers have of late years lagged behind in the development of steam-driven plants. In the past it was the marine engineer who was mainly responsible for the popularisation of triple expansion engines and of what used to be considered high-pressure steam. This was probably due to the fact that powers at sea ruled larger than on land, and a more skilled engine-room staff was employed at sea than was customary in land service. To-day conditions are reversed, 5,000 h.p. represents a fair-sized marine installation, whilst a unit of this output would be regarded as small in a land power station.

The outcome of the contest between the two rival methods of ship propulsion will, on the one hand, turn upon the possibility of improving the thermal efficiency of the steam plant and on other on the possibility of reducing the cost

and weight of Diesel machinery. As matters stand, the best types of turbine can hardly be improved mechanically, but its average thermal efficiency at sea can certainly be considerably increased. On the other hand, there seems little prospect of any material increase in the thermal efficiency of the Diesel engine, but its weight and cost ought to be capable of reduction. This may involve an increase in rotational speeds, and it is possible that this may revive some of the engine-room troubles which vanished on the introduction of the turbine. Destroyer trials were a serious anxiety to the builders of reciprocating engines, and there were several disastrous accidents from connecting-rod fractures. No doubt a smash of this kind would be a much less serious matter with a Diesel engine than it was with steam, where the whole engine-room complement ran the risk of being scalded to death. Nevertheless, it cannot be denied that high-speed reciprocating machinery is more subject to fracture than that in which the motion is purely rotary, and considerable circumspection will be required in improving the Diesel engine along this line of advance. No doubt the difficulties can be overcome, and it is not a little extraordinary that certain motor bicycle and small motor-car engines attain 3,000 r.p.m.—a speed which at the beginning of the century was considered too high for turbines of more than some 500 kw. rating.

From the purely academic standpoint, there is certainly something very attractive in the idea of a prime mover complete in itself. With steam the fuel is burnt in one component of the plant, and the useful work produced in another, whilst in the internal combustion engine the conversion of the chemical energy of the fuel into power is effected in a single unit. Short cuts of this kind are alluring, but experience has shown that in many departments of industry the short cut is not always preferable to the longer way round. In the Catalan forge, iron was made directly from the ore, but no great development of iron and steel manufacture was possible until a much more complicated method of reduction was elaborated, and this experience has been paralleled in other trades. Simple and direct processes generally imply the use of "raw materials" of somewhat exceptional quality, and though builders often claim that the Diesel engine can be run on indifferent oils, these are not in favour with users. In this lies the possibility of the successful competition of steam with the marine Diesel engine, and the advantage which it has in this regard may be increased if certain modern methods of using coal be extended to sea service. At one American power station it is reported that the boiler room is furnished like an office. All grime and dust are excluded, and the coal is handled and used with as little trouble or nuisance as oil, the boiler-room crew being reduced to a mere skeleton of what was formerly required.

It is on this question of fuel costs, direct and indirect, that the contest for supremacy will ultimately turn, and on this head the last word on behalf of steam has still to be said. In the matter of reliability, the Diesel engine appears now to be satisfactory. The testimony in this respect of Mr. Ruck-Keene, Chief Engineer-Surveyor of Lloyds, given in the discussion at the Institution of Naval Architects, may fairly be regarded as authoritative. He declared that in the actual operation of Diesel ships the adjustments which had to be made to the propelling plant were far fewer than was the case with steam.

Both the rival types of prime mover are handicapped by the demand of the propeller for a low rate of revolution, and any considerable diminution in the weight of the Diesel engine would probably involve such an increase in the rotational speed as to render necessary the introduction of gearing between the crank shaft and the propeller shaft.

WATER ENCROACHMENT IN OIL FIELDS.

THE flooding of oil wells is, fortunately, not so disastrous to drillers as the flooding of coal mines. But the oil-producer has many reasons to dread the appearance of water, which generally means serious trouble, and not uncommonly forebodes the approaching exhaustion of the well, if not of the field. Water troubles have been mentioned in almost every paper on oil production brought before the Institution of Petroleum Technologists; the paper entitled "Notes on Water Shut-off," which Mr. F. G. Rappoport, M.Inst.C.E., communicated to the Institution at a recent meeting, was probably the first to be devoted entirely to this particular subject.

The oil, gas and water occurring near one another underground, in the same or in different horizons, separated or not by impervious layers, will be in natural equilibrium until this equilibrium is disturbed somewhere by drilling or some other cause. Water may then displace the oil and gas, and become "edge water or bottom water." But it does not follow that the oil and gas will rise. Water easily displaces oil from coarse oil sands, but not from fine sands, and the oil may become entrapped again. Edge water proper, coming from a source in the oil field itself, and releasing the oil as it advances, cannot be radically excluded by mechanical means, though palliative measures may be adopted. Water coming from outside sources, originally separated from the oil, can be dealt with mechanically, whether it is a case of "top, intermediate or bottom water." Mr. Rappoport's paper showed that the drill frequently passes through several water-bearing strata alternating with oil layers, and that the problems of the geologist, who explores the formations, the chemist who assists him in determining the character of the strata and of the oil and water found, and the engineer who has to exclude the water, are very complex.

At Grosny, all the water-bearing horizons are above the main oil sources, and the lowest source of water is separated from the oil by an impervious layer too thin for effectual water shut-off. The Maikop (Caucasus) and the Boryslav (Galicia) oil fields are examples of "creep" or edge water. At Maikop two water sources, one characterised by sulphuretted hydrogen, the other by carbon dioxide, lie between two oil sources. Edge water encroaches up dip as oil and gas are withdrawn, usually at an irregular rate; the water inrush of 1910 in Galicia was very sudden and rapid. Top water will follow the well in its drilling course and may, unless prevented, enter porous beds and carry water to other strata and wells. If the water is under an initial head, that pressure will further increase with the depth of the well, and it should be utilised to force up the oil. But it may also force up water, and when the oil pressure is, or becomes less, than the hydrostatic water pressure, the oil will be held back and the oil stratum be flooded or wetted. Bottom water, struck below the oil source, may also be under considerable hydrostatic pressure and may rise and flood the oil above; the location of bottom water is, hence, important. Water intermediate between two oil sources may be dealt with by exhausting one oil sand and then proceeding to the other, allowing the first to be flooded. Knowledge of the geological formation can be secured by carefully drilling test wells; any water struck is shut off before the final casing is decided upon. At Grosny three water sources were sealed off simultaneously. In the Yenangyoung field, Burma, water is shut off at about 1,000 ft. depth, and nothing further is required; in the Singu field, water trouble is met with only at 2,000 ft. Knowledge of such facts means considerable saving in the cost of casing. Once water is admitted into the oil source, exploitation must be continuous, though prices at the time might make it preferable to leave the oil underground. In the Baku oil fields, water gained headway during the political troubles of 1906, and the field never recovered properly. Water causes serious trouble also by the formation of water-oil emulsion, and defective casings are specially objectionable for this reason.

The chemist's share in the prevention of water difficulties is not large, but important. The chemist can help by analysing specimens of soil, mud and water brought up as to new constituents, indicating that new strata or waters from different sources are being struck; the source can also be traced by the aid of aniline dyes. When wells are plugged, analyses should be taken from point to point, and the results tabulated for future reference. Mr. Rappoport referred in this connection to Bulletin 429 of the United States Geological Survey on "The Geochemical Interpretations of Water Analyses." The chemist has, further, to see that the materials which the engineer requires for stopping water are of the required qualities. The most important of these materials is cement. Mr. Rappoport recommended highly-burnt pure Portland cement, mixed with 40 per cent. of water, so as to set in a suitable time (from 7 to 12 hours); for grouting under pressure, a thicker mixture may be used. It may here be stated that Mr. A. R. Neeland mentioned during the discussion that pressure would reduce the setting time, and Professor Nash recommended the hydraulic cement used in harbour construction. Mr. Rappoport further pointed out that, even with great care, the cement might come in contact with the well water, the influence of which should be predetermined, and also with the oil. The presence of oil, it had been observed at Baku and confirmed elsewhere, had little effect on the hardening time, but gas and agitation would retard and prevent the setting and hardening, while heat hastened it.

The application of the cure for water trouble falls to the engineer. In the early attempts to stop water inflow, made at Baku in 1890, the materials tried comprised asphalt, clay, alabaster, and fine sand. During the last twenty years progress has been made particularly in America, and the chief material used is cement; clay and mud also find application. But an auxiliary material may not be required at all. When the ground is sufficiently plastic, top waters may be shut off by pressing the casing into the non-under-reamed part of the hole, a long form of casing shoe being used; heavy mud may also be run between the casing and the well wall. This method is not reliable in soft, loosely held formations, but has been found of service in Rumania and on the Yenangyoung field.

In the tubing method, used when large quantities of cement have to be placed quickly under ordinary or high pressure, the casing is first raised off the bottom. The casing head is closed by a screw-head and water poured through a central tubing extending far down, the water (or mud) finally rising in the space between casing and wall; this circulation ensures a clear space for the cement. Cement is then pumped down the same tubing, and the casing is lowered again, when the weight of the casing and of the water force the cement up into the annular external space. Mr. Rappoport gave particulars of the placing 35 barrels of cement by means of 2-in. tubing in a Burma well. The plug methods, which he illustrated by reference to the double-plug process of Perkins, dispenses with the string of tubing for conveying the cement down to the point where the water is to be shut off. Circulation of either water or mud must first be obtained, as just mentioned. The casing head is then removed and the first plug inserted. This is a cylindrical piece of soft wood, thick below and provided there with perforations. Cement is put on the top of the plug, and a second wood plug, inverted and not perforated, is inserted into the casing; the second plug is fitted with a spacer rod. The casing head is fixed again, and the cement and plugs are forced down by means of water or mud. When the first plug settles on the bottom, some cement is forced out through the perforations and spreads round the shoe.

Various modifications of these processes have been introduced, by Halliburton, who uses a steel tape and bob for checking the position of the upper plug, and by others. Cementation is largely done by contract with the aid of portable pump and cement-mixer outfits. In some cases mud of clay or shale may effectually be used for shutting-off water and even gas-sands, not only temporarily, and for protecting the casing against corrosion. The mud may be mixed with cement. But the cement, mud, and water affect the oil sands in different ways, especially when applied under pressure to save casing, and new wells behave differently in that respect from partly drowned wells. Another point to which Mr. Rappoport drew attention is the fact that casings are still tested under internal pressure, whilst they often collapse under external pressure.

THE GRENOBLE EXHIBITION.

AN exhibition was officially opened in the latter half of last month at Grenoble, in France, which should have a good deal of attraction for engineers. The full title of the exhibition is L'Exposition Internationale de la Houille Blanche et du Tourisme, from which it might be imagined that the whole would form rather an incongruous combination. Actually the idea does not appear to have worked out at all badly, though engineers who may visit it with purely professional purposes in view will probably find a good deal to skip. The difficulty of making an effective exhibition in connection with hydro-electric work must be patent to all, since the intricacy of the problems to be tackled is so intimately coupled with the topographical conditions of sites and districts. The result has been that the greater part of the material to be inspected in the main building devoted to this section of engineering, consists of models, photographs and drawings, giving particulars and details of schemes recently perfected, in course of completion, or projected. A very large variety of work is covered, ranging from high to quite low falls, so that the collection is likely to be of a very instructive character. There is, in addition, a certain amount of machinery to be seen, and machine parts, both in the main hall and in the machinery annexe, but it is difficult to say at present what interest this may possess. The exhibits of this class are not, however, numerous enough to form the main attraction of the section, which to most engineers will, we imagine, lie in the examples of solutions of problems presented more by the character of the undertakings themselves, than of the machine equipment. A certain amount of high-tension and other switchgear, transformer plant, &c., is to be seen, including transmission towers, outdoor switchgear framework, and so on. The main interest will centre in the principal buildings, which are occupied by France. There is also a foreign section, in which, however, space does not appear to have been taken up in a manner very representative of the international character of this branch of engineering, while Sweden and Italy each has a building of its own, each staging a certain number of exhibits connected with hydro-electric developments.

To engineers, the remainder of the exhibition offers some further attractions. One building devoted to railways contains examples of the latest French and Italian electric locomotives, as well as other examples of rolling-stock such as saloon and other modern types of coaches. It is something of a compliment to this country that the chief historical exhibit, in fact the only one in the building at present, should be a Stephenson locomotive exhibited by the P.L.M. Company. In another building is to be seen a series of early motor-cars, while in yet another, by way of contrast, can be seen a collection illustrating the latest developments in air travel, including examples of the furnishing of passenger-carrying machines, types of engines, models of wind channels, &c. The exhibition appears to have been well supported by the Government and public bodies. Technical exhibits by ministries are numerous and extensive, and there are many contributions from the universities and colleges, several of which, of course, devote special attention to hydro-electric subjects. One of the Government exhibits is concerned with forestry and the training and regulating of mountain streams and torrents, and in this building are shown examples drawn from all the mountainous regions of France; as these differ so materially in character, the variety of work is naturally considerable.

The district surrounding Grenoble, itself full of hydro-electric works of various kinds, is an excellent one to visit. The country is among the most attractive of the higher Alpine regions of Europe, and engineers visiting it could without difficulty plan both a pleasurable and instructive holiday. The exhibition will be well worth attention, while innumerable examples of installations are within easy reach. A word of warning must, however, be given to engineers who really wish to profit by the Exhibition. The state of the whole undertaking is still very far from complete, and, judging from the present condition, some time must elapse before visitors will be able to inspect in any detail the finished exhibits, or the necessary facilities will be available for information to be obtained concerning them. In fact, the most advanced exhibit at present would almost seem to be the old Stephenson "Pierrot"—delivered to the P.L.M. in 1846 and withdrawn from service in 1866. This old machine is in a fine state of preservation, and is very smart in appearance, but requires the support of other exhibits, still in a very nebulous state, to warrant a visit from any great distance.

THE PHYSICAL CHEMISTRY OF STEEL-MAKING PROCESSES.

A JOINT general discussion on the physical chemistry of steel-making processes was held by the Iron and Steel Institute and the Faraday Society on Monday, June 8, in the hall of the Institution of Civil Engineers, London.

In his introductory address, Sir Robert Hadfield stated that the basic reactions of steel manufacture depended upon some chemical reaction or displacement in a somewhat viscous liquid phase, and the resulting changes were largely influenced by temperature conditions. The chemical changes which occurred were, therefore, governed by thermodynamical laws. One of the chief difficulties in carrying out high-temperature researches on materials of special purity was the construction of a furnace of suitable type and materials of adequate refractoriness to prevent contamination of the melt with impurities from the furnace linings. Consequently, the future development of all classes of steel-making processes depended, to some extent, upon refractory materials research.

The first paper taken was entitled "Balance Reactions in Steel Manufacture," by Dr. A. McCance, who stated that many reactions of varying importance took place in the open-hearth furnace. An equation representing an ordinary fundamental reaction could be treated algebraically and other reactions derived therefrom. He illustrated his point by equations connecting the reduction of iron oxides by carbon monoxide. His algebraical method could be further extended to cover a series of physico-chemical reactions taking place in the furnace.

"A Study of the Reaction of the Basic Open-Hearth Furnace" was the title of the paper next taken. It was by Mr. T. P. Colclough, who first of all showed the important nature of the oxidation due to the gases of the furnace atmosphere. Slag and metal were exposed throughout to a powerful oxidising action, even when ore additions were not being made. The relative rates of oxidation of carbon and phosphorus depended primarily on the basicity of the slag. At the tapping stage, if there were not sufficient CaO present to satisfy both the SiO_2 and the P_2O_5 completely, there was grave danger of an increase of phosphorus in the metal on re-carburising in the ladle. Hence, the stability of phosphorus in re-carburising depended upon the basicity of the slag and had no relation to the state of oxidation of the slag. In basic practice, the return of manganese from slag to metal had been observed, and it had been suggested that the distribution of manganese depended upon the ratio of MnO to FeO in the slag. He submitted that the distribution of manganese was not determined by one simple factor, but was the net result of a series of reactions, and that the basicity and FeO contents of the slag were vital factors. Further, there existed a close parallelism between the distribution of manganese and the process of desulphurisation. He was of opinion that in certain slags the formation of calcium ferrite, a compound of lime and ferric oxide, was a probability.

The paper by Mr. F. T. Sisco on the "Chemical Reactions of the Basic Electric Process" was read by Dr. W. H. Hatfield. It stated that, in the basic electric furnace, the scrap was melted under oxidising conditions which could be closely controlled. The silicon was oxidised and held by the slag, and variable amounts of manganese and carbon were oxidised, the former passing into the slag and the latter escaping as carbon monoxide. By carefully controlling oxidation and regulating the temperature, most of the phosphorus passed into the slag as calcium phosphate. After complete oxidation, the slag was removed and the metal recarburised. The final period of the process consisted of deoxidising and desulphurising the metal by means of a very basic slag containing an excess of carbon or calcium carbide. Fluorspar was used to give fluidity to the slag, and accomplished this with but little sacrifice of basicity. This fluidity was the result of the presence in the slag of fluorides and silico fluorides. Fluorine was very active, and exercised a corrosive effect upon the furnace refractories.

The above three papers were taken together for discussion. Professor F. G. Donnan spoke first, and said that the great depression in the steel trade did not appear to affect the scientific side of the industry. As a result of the work done by the authors of papers in the bringing together of equations, constants which applied in practice as well as from a scientific point of view had been obtained, and the basis of equilibrium conditions in the steel furnace had been well established.

The general discussion turned chiefly upon the effect of temperature on various reactions and also on the question of the solubility of ferrous oxide in iron and steel. A practical suggestion was made by Professor C. H. Desch, who proposed the standardisation of equilibrium constants. Stress was also laid on the construction of the steel furnace, the size of the flues and the volume of the gases, all of which points were of great importance in the working of a charge. The effect of temperature had not been emphasised sufficiently. Mr. Harbord agreed that the relative rates of oxidation of carbon and phosphorus were primarily dependent upon the basicity of the slag. On the question of deoxidation, attention was drawn by Dr. W. H. Hatfield to the evolution of gas from the steel during freezing, and he asked as to the possible effect of this upon Dr. McCance's formulæ. Dr. Hatfield questioned whether FeO was soluble in liquid steel containing carbon, although it was soluble in iron. Research workers had shown that in a steel with less than 0·05 per cent. of carbon, pearlite could not be seen under the microscope, the inference being that the carbon was in solution. It had also been ascertained that 0·05 per cent. of oxygen could exist in solution in steel. One could readily assume, therefore, that this carbon and oxygen might be in combination as carbon monoxide. However this might be, it was well known that steel when heated to 900 deg. C. for long periods, still gave off carbon monoxide. That hydrogen was scarcely a reaction product, but was probably absorbed by the steel from the furnace atmosphere, was suggested by Dr. Rosenhain. If the hydrogen were desiccated first, complete deoxidation of the molten iron was obtained. Temperature was all-important in regard to the oxidation of metals and metalloids. Under certain conditions, so basic a material as magnesia could be decomposed by a metal of the iron group. Attention was drawn to the way in which, in iron heated over long periods, the oxide penetrated along the grain boundaries. This afforded no evidence that the oxide had dissolved.

The three next papers were taken together. Of these, one by Mr. J. B. Ferguson was entitled "Equilibrium in Systems involving Ferrous Oxide." It stated that, although much work had been done upon the systems Fe—O—H and Fe—O—C, there was still a lack of agreement in respect to the most fundamental points. The author believed that the ferrous oxide phase had a bearing upon the discrepancies. Fairly conclusive evidence had been obtained which showed that the ferrous-oxide phase was variable in composition. This at once opened up the question as to the probable effect upon the transformation temperature of ferrous oxide produced by the solution of ferro-ferric oxide. On cooling ferrous oxide, it decomposed into ferro-ferric oxide and free iron. A lowering of this temperature, somewhat similar to the lowering of the β—γ inversion in pure iron by the solution of carbon, might be expected. Such a change in the transformation temperature would provide an explanation of the many futile efforts which had been made to prepare pure ferrous oxide.

The next paper was on the subject of slag reactions, and Dr. P. M. Macnair, the author, opened by saying that the viscosity of the slag in a steel furnace was an important factor in determining the rate of chemical reaction. The slag tended to

become more viscous owing to its contact with the lining, and the inactive stage in steel-melting operations was set up due to the increased viscosity of the slag. This was not necessarily a state of equilibrium. In acid practice, the slag became viscous and inactive when it contained 60 per cent. of silica. In basic slags, the inactive stage was reached at about 60 per cent. CaO, 40 per cent. SiO_2, and low FeO. He suggested that these inactive slags be called "slags of limiting composition" or "limiting slags."

The third paper was by Mr. J. H. Whiteley and dealt with "The Function of Ferric Oxide in Acid and Basic Open-Hearth Processes." The author stated that, at high temperatures, ferric oxide was readily reduced to ferrous oxide by metallic iron. This fact enabled the ferric oxide to function as a carrier of oxygen, since the ferrous oxide formed was readily oxidised again and under suitable conditions the process might continue indefinitely. In the acid process, while a vigorous boil was in progress the ferric oxide in the slag remained well under 0·50 per cent.; even a heavy feed of ore did not appreciably alter it. As the carbon dropped below 0·20 per cent., however, the ferric oxide began to increase and might reach 3·0 per cent. There could be little doubt, that throughout the boiling period, ferric oxide constantly functioned as a carrier of oxygen, since 50 per cent. of the carbon might be removed by gas-oxidation in normal working. Thus, gas-oxidation by the agency of ferric oxide, accelerated the process, although it did not, like ore-oxidation, improve the yield. In the basic process, the same effects were to be observed to a still greater extent; during the refining period the ratio of ferric oxide to ferrous oxide was invariably much higher than in the acid process.

In the discussion, the statement was made, referring to Dr. Macnair's paper, that too much emphasis had been laid upon the absorption of silica from the banks and furnace lining. The increase of silica was due to the reaction between the metal and the slag.

The last paper taken was on the "Micro-examination of Steel-Making Refractories," by Mr. W. J. Rees, who read it in abstract; he illustrated his remarks by a large number of lantern slides. Stress was laid upon the very great importance of the subject, inasmuch as the temperature in the furnace was limited by the physical characteristics of the refractories. There were three general methods used in the micro-examination of refractory materials. Thin transparent sections could be prepared and examined by transmitted light; the second method involved the examination of flat polished surfaces by means of reflected light; the other method was the examination of powdered material. The texture of fractured or corroded surfaces could also be examined by means of a low-power lens. The preparation of thin sections required great care in grinding. Slides shown illustrated the great advantage of ganister for the manufacture of fire bricks, as the grains of the material were small, uniform in size, and angular. In this respect, ganister from the Sheffield district was distinctly preferable to similar material from the United States, which had a much coarser grain. An interesting point brought out was that the more thoroughly a silica brick was burnt, the greater was the care required in building it into the furnace; heating had to be slow in the early stages to avoid the production of mechanical strains giving rise to cracks and spalling. The examination of used silica bricks gave much information regarding the requisite seasoning. When seasoning had been satisfactory, the durability of the roofs and side walls of the furnace was greatly increased.

Mr. R. J. Sarjant, in the discussion which followed, called attention to the developments carried out at Messrs. Hadfields' works in connection with the microscopical study of refractory materials. He showed various samples of slags, refractory materials and sands and emphasised the value of the petrological microscope in the scientific control of steel-making processes and materials. One of these microscopes formed part of Messrs. Hadfields' exhibits at the meeting. The microscope was found very useful in that it defined the impurities rather better than did chemical analysis. Greater co-operation was advocated between the steel-maker and the manufacturer of fire-bricks with a view to arriving at the most suitable product. Hitherto there were no satisfactory inspection tests for magnesite bricks and other materials of the same nature. Mr. A. F. Hallimond, of the Geological Survey and Museum, considered the author's statements to be a clear exposition of established facts and his results to be in close agreement with those published by the Geological Survey. In regard to the preparation of thin sections of refractories, he added that the Survey were able to prepare thin sections of iron ores which were more difficult materials to deal with than refractories. With reference to Mr. Rees' comparison between the Sheffield district ganister and the American product, it was stated, in the course of the discussion, that a large amount of the former was exported to the United States.

The last paper on the list on "Physico-Chemical Phenomena from Melt to Ingot" was contributed by Mr. A. L. Feild, of New York. It was taken as read.

Votes of thanks to the authors, to the Institution of Civil Engineers for the loan of their premises, and to the chairman, concluded the proceedings.

THE INSTITUTION OF GAS ENGINEERS.

THE annual general meeting of the Institution of Gas Engineers was held on Tuesday, Wednesday and Thursday of this week in the Great Hall of the Institution of Civil Engineers. Mr. J. Ferguson Bell, M.Inst.C.E., chief engineer and general manager of the Derby Gas Company, presided over the various proceedings, and papers of importance to the industry as well as reports of the various Institution committees were presented and discussed. Visits were made by the members to the National Physical Laboratory, Teddington, to the Fulham works of the Gas Light and Coke Company to view plant in course of erection, and also to the laboratories and gas-burner manufacturing shops of the South Metropolitan Gas Company. At the conclusion of the proceedings the members journeyed to Derby and visited the London, Midland and Scottish Railway Works, the Litchurch and Cavendish-street Gas Works, and the Royal Crown Porcelain Works.

At the opening session on Tuesday morning, after formal business had been transacted, the Birmingham medal of the Institution was presented to Dr. Charles Carpenter, and the H. E. Jones London medal to Mr. R. E. Gibson, M.Inst.C.E., for a paper on "The Construction of New Coal-Gas Works at Garston, Liverpool." Diplomas in Gas Engineering, awarded under the Institution's education scheme, were also presented to the successful students. Mr. Charles Hunt, Alderman Fred J. West, Lord Mayor of Manchester, and the presidents of many Dominion and foreign gas associations were next nominated as honorary members of the Institution.

Sir Alfred Mond then outlined the proposals embodied in his scheme for dealing with the reduction of unemployment. If men who are at present in receipt of unemployment insurance benefit and the other types of relief contributions, were put back to work, the funds which would otherwise have been used as doles would be available as subsidies to firms obtaining orders, and would enable them to compete against the prices quoted by foreign firms. Once such a scheme of deflecting the relief from the men to the firms who could obtain work was effected, a continuous growth of demand for the products of every type of industry would result, and eventually work might be provided for the great mass of men who are now out of work.

In the course of his Presidential Address, Mr. J. Ferguson Bell stated that in the last five years the output of gas had increased from 242 thousand million cub. ft. to 282 thousand million cub. ft. Incidentally it was contended that the Gas Light and Coke Company, the largest concern of its type in the world, supplied a greater output, measured in heat units, than the combined output of all the electricity undertakings in the country. Later in his address the President protested strongly against the proposals that have been put forward that Government assistance should be given to bring about the reorganisation and expansion of the electricity supply industry by the issue of Electricity Bonds guaranteed by the Government. This he regarded as unfair to the gas and other industries. Artificial stimulus to any industry by means of State aid was, he said, without precedent, and was essentially contrary to the financial and fiscal policy of the country. Cheap electricity, he contended, was not a panacea for all industrial ills, and as compared with production costs for materials, labour, rates and overhead charges the cost of power was only from 1·0 per cent. to 5·0 per cent. The electrical industry was sufficiently prosperous to pay for any schemes which would result in a fair remuneration on the capital expended. The setting up of super-power stations by means of Government assistance entailed the shutting down of a large number of municipal stations, and deprived the municipalities of the control of their own works. Financial assistance to the electricity supply industry must injure municipal enterprise in what was, probably, its most successful department—that of gas supply. The President then contended that no case had been made out for any subsidy being granted to the electrical industry, and that if such a policy were pursued all competitive trades and industries should receive similar treatment, and that such subsidies should take the form of loans repayable with interest over a period of years in a manner similar to the loans to municipal trading departments.

There were in the year 1923 in Great Britain 790 companies and local authorities with gas undertakings, and these supplied 7,810,350 consumers through an aggregate of 40,980 miles of gas mains. Over 181 million gallons of tar were produced in the process of manufacture of the 260 thousand million cub. ft. of gas, and 117,166 tons of sulphate of ammonia were obtained. From trustworthy data the thermal efficiencies obtainable per ton of coal or coke used in good ordinary practice with modern plants were given in the table below.

—	Quality of Gas B.Th.U. per cub. ft.	Gas Per cent.	Coke Per cent.	Tar Per cent.	Heat used and lost in manufacture. Per cent.	Thermal Efficiency of process Per cent.	Efficiency of Gas Production
1. Horizontal retorts	550	24·97	48·12	5·61	21·30	78·70	54·0
2. Do., with water-gas added	500	28·17	42·12	4·89	24·82	75·18	53·2
3. Vertical retorts with steaming by waste heat boiler	450	29·19	40·60	7·68	22·53	77·47	56·4
4. Blue water gas with waste-heat boiler	300	62·50	—	—	37·50	62·50	62·5
5. Carburetted water-gas with waste-heat boiler	500	68·00	—	1·75	30·25	69·75	69·2
6. Low-temperature carbonisation	700	13·61	55·33	10·87	20·19	79·81	40·3
7. Complete gasification	340	64·26	—	1·00	34·74	65·26	64·9

From these figures it was seen that there was not much to choose, in thermal efficiency, between the best horizontal and vertical carbonising plants, but it was necessary to bear in mind that a high number of therms per ton of coal used might be uneconomic as compared with a lower production by using cheaper grades of coal and smalls; especially was this the case with those undertakings near the collieries.

At the conclusion of his presidential address, a vote of thanks was accorded to Mr. J. Ferguson Bell on the motion of Dr. Charles Carpenter, seconded by Mr. Henry Woodall. The annual report of the Council for the previous year was then presented and adopted, after which Mr. F. W. Goodenough dealt with the work of the Advisory Committee on Education. Instruction in gas engineering was, he said, now given in 23 centres, and during the last

year 110 students had presented themselves for examination.

Professor J. W. Cobb then presented the thirteenth report of the Gas Investigations Committee, dealing with Aeration of Lighting Burners. Mr. J. W. Wood followed and pointed out some of the deductions made in the course of the experiments. From a large number of observations they had found that the degree of aeration by primary air obtained in a ordinary lighting burner, working normally and satisfactorily, was less than half that necessary for complete combustion. This indicated the order of importance attaching to the construction of those parts of a burner and its accessories which influenced the supply of secondary air. One factor in aeration was the specific gravity of the gas, which had an influence on the injecting power. Some careful work had been conducted which showed that the apparatus devised by Mr. Blackie of the Fuel Research Station at Greenwich could be used with accuracy and reasonable celerity in the determination of the specific gravity.

Later Professor J. W. Cobb presented the fourteenth report of the Gas Investigation Committee, in which there was given a description of the experimental gas plant at Leeds University, which was installed as a memorial to the late Sir Corbet Woodall. Dr. A. Parker said that the installation was not in any way intended to be a small-scale model for gas works, but contained many features which differed greatly from usual practice. It was therefore necessary that preliminary trials should be carried out before a programme of research work could be embarked upon. Some of these tests have now been completed and the suitability of the horizontal units and auxiliary plant as a carbonisation plant had been established. The report concluded with a note on a method of preparing coke sections for optical examination, in which a white cement was used to fill the pores and cracks of a plane section prior to polishing. It was believed that the method would prove valuable when comparisons had to be made between the cokes obtained from different coals and by different methods.

Tankless Gas-Holders.

In the afternoon Mr. J. Ferguson Bell again presided, when M. Baril presented a paper entitled "Notes on the Tankless Gas-Holder at the Etablissements Arbel Douai, France," contributed by M. L. Rolland d'Estape. In this a description was given of a design of gas-holder in which the tank and its large volume of water were eliminated. In the construction of the tankless gas-holder a simple vertical cylinder with a fixed base is fitted internally with a moving disc, which has a gas-tight packing. The installation described was the first of its type built in France, and it has a capacity of 970,000 cub. ft. The shell is made from $\frac{1}{8}$-in. plate and is in form a 26-sided polygon. The disc is guided by means of rollers and rises and falls under the pressure of the gas. Actually the height from baseplate to the eave of the roof is 118 ft., the diameter of the circumscribed circle of the shell is 111 ft., and the stroke of the disc is 101 ft. A fluid seal is provided between the moving disc and the shell by the use of tar supplied by pumps.

In opening the discussion Mr. J. P. Leather suggested that the tankless gas-holder was even more unsightly than the common type. He thought that as the holder presented a large area to the wind it was possible that deflection would ensue and the internal disc would then leave varying spaces between it and the holder. Leakage might possibly be caused by wind actions in this way. Mr. Milburn stated that he had looked over the plants erected to discover possible disadvantages. He contended that the design was much better fitted to resist wind pressure than the ordinary type. As corrosion did take place in gas-holders, it was an obvious advantage to have the interior continuously covered with tar. Usually the disc was a good fit without any seal, and therefore the danger of leakage due to wind action was not great. Outside Great Britain there were few, if any, spiral type gas-holders, and if it became a question of competition between this form and the tankless type it would be found that they had advantages for certain sizes. Mr. Gill stated that when he was in America recently he was informed that tankless gas-holders were under construction to deal with 65,000,000 cub. ft., among which there were some units of 15,000,000 cub. ft. each. Other speakers called attention to the number of pumps which were fitted to deal with the tar.

M. Baril, in reply, stated that where wind pressures were excessive, it might be necessary to make special provisions to obtain rigidity for the gasholder, and that could be easily done, as the tankless gasholder was much cheaper than the ordinary type. Where the wind pressure was great, it was possible to increase the diameter of the holder and reduce its height. There were spacing pieces around the disc, and it was necessary to fill each tar compartment, which was done with separate pumps.

New Carbonising Plant.

Mr. W. M. Carr then presented his paper on "Selection, Design and Construction of New Carbonising Plant at Stretford." In this he stated that from the economic standpoint the most desirable carbonising plant was that best equipped to meet the variations in the commercial values of the coal and the residual products. The main points affecting the selection of the plant were that it should be capable of successfully carbonising fine slacks, the gas produced must have a high calorific value to defer as long as possible capital expenditure to provide storage and mains of increased capacity; capital cost had to be kept down and the plant had to be of suitable design to reduce to a minimum all laborious work. An electrically driven telpher system was adopted for coal handling, and could be fed from either the canal or railway adjoining the works. Either gas or coke firing was possible for the horizontal retorts. A marked departure from the standard practice in this country was afforded by the adoption of Congdon scrubber standpipes in place of ascension pipes and hydraulic mains. An improved scrubber standpipe was designed by the author to meet the requirements. The coke is removed by a high-speed telpher on to an external quenching bench, from which it is carried through a hopper to a coke breaker and elevator.

Mr. Toogood opened the discussion, and commented on the unique character of the installation as the retort house was situated between a railway and a canal. By the use of the telpher system it was possible to blend the coal to obtain uniform working. Mr. Collett asked whether the retorts were made of 95 per cent. silica. He noted that the hot liquor was taken from the standpipes to a tank and then recirculated. This liquor, being hot, must cause trouble with the pumps and pipes. Coke quenching was better done with hoses in front of the retorts than by the use of a telpher system. Mr. Leech agreed with the author's decisions to use horizontal retorts, but thought that better yields and working were sometimes obtained with smaller sizes of retorts than those used at Stretford. He noted the limit set by Mr. Carr on the combustion chamber temperature as 1,350 deg. C., but had no knowledge of any troubles that might lead to the selection of that limit. Mr. R. E. Gibson called attention to the fact that if everyone decided to use slack its price in the market would rise immediately. There were places where no coke breeze, such as was used by Mr. Carr, could be obtained. Mr. Hardy thought that the new Congdon pipes were responsible for the good results obtained at Stretford.

Mr. Carr, in reply to the discussion, said that the retorts were made of 95 per cent. silica. The temperature of the liquor was undoubtedly high, and better results could be obtained if cooling were resorted to. In the new tanks the temperature of the liquor would be reduced by the use of waste heat for feed-heating purposes. No difficulties had been experienced in pumping the liquors at 170 deg. F., and there were no signs of deterioration. With the coke telpher systems the complete series of operations would, it was hoped, be performed in 1 minute 20 seconds. The section of retort chosen, 24 in. by 18 in., was adopted because that size was thought most suitable for charging with a simultaneous machine, but the size was also the best from consideration of the types of coal they had in Lancashire and Yorkshire. The intention of using a separate producer to obtain gas for retort heating was adopted as a means of using coke breeze, and also fine slacks, to economic advantage, and similar results might be obtained where cheap fuels were available. The meeting then accorded the various authors a hearty vote of thanks.

(To be continued.)

THE INSTITUTION OF ELECTRICAL ENGINEERS; SUMMER MEETING.

Owing in the main, we believe, to the World Power Conference and the large number of its members which was attracted to London by the British Empire Exhibition, the Institution of Electrical Engineers did not hold in 1924 the summer meeting which is tending to become such a regular function. This omission naturally adds to the interest of the present meeting, which is being held at the South Midland centre, and which opened on Tuesday morning by a visit to the Prince's Power station, Nechells, of the Birmingham Corporation. The City of Birmingham has naturally been made the headquarters of the meeting in the district of which it is the centre, but the progamme includes visits to engineering works and places of interest as far away as Coventry, Rugby, Stratford-on-Avon, Evesham, Warwick, and Stourport. The meeting, which is being presided over by the President, Mr. W. B. Woodhouse, has attracted some 330 members and ladies, and the Institution is fortunate in the presence of Mr. R. A. Chattock, the Birmingham City Electrical Engineer and the President-elect. Mr. Chattock's position in, and knowledge of, the district concerned cannot but add to the success of the meeting.

It is always difficult to write a fair and reasonably complete account of a meeting covering a variety of activities in a comparatively brief space, and, without further discussing the functions in general terms, it will be well to begin at once a chronological account of the proceedings. As we have already said, these began with a visit to the Prince's Power Station, Nechells. This station we described, and illustrated, in very considerable detail in the early part of 1923,* and we need not now attempt even to summarise any great part of what we said then. The station, however, embodies many features of particular technical interest, to some of which we may refer. It contains four 15,000-kw. turbo-alternator sets, thus having a present normal capacity of 60,000 kw., but three further sets are now on order and will raise the normal capacity to 90,000 kw. or the overload capacity to 111,000 kw. This is the capacity for which the station was ultimately designed, and the progress of electricity supply in the Birmingham area is clearly illustrated by the fact that the completion works are already in hand for this station, which was put on load as recently as the late summer of 1922.

It will be generally known that the area in which the Institution of Electrical Engineers is meeting is one of those in which electricity supply has been co-ordinated under the auspices of the Electricity Commissioners, and that the machinery of the South-West Midlands Electricity District is now in operation. This machinery consists of an advisory committee representing the Birmingham Corporation and the Shropshire, Worcestershire and Staffordshire Electric Power Company, two bodies which between them supply 98 per cent. of the electricity in the area. A complete technical scheme has been worked out for the ultimate supply of the whole area from three capital stations. Of these three stations Nechells is the only one at present in operation. The others are the Stourport station of the Power company on the River Severn and the projected Hams Hall station of the Birmingham Corporation. The Stourport station, which is to have an ultimate capacity of 105,000 kw., is at present under construction, and forms the object of one of the visits of the summer meeting. The projected capacity of the Hams Hall station is at least 300,000 kw.

The new station at Stourport, is situated on the

* See Engineering, Vol. cxv, page 99, *et seq.*

River Severn, in a good position for a supply of condensing water, but when Nechells was built it was not possible to find a site within reasonable distance of Birmingham with similar advantages. This condition, as a matter of fact, largely determined the location of Nechells, which was placed in the neighbourhood of the works of the Birmingham Tame and Rea District Drainage Board in a position in which an abundant supply of filtered sewage effluent was available. The rather novel decision to utilise this material for condensing has been entirely successful, and the same scheme is to be employed at Hams Hall. As already stated, the Nechells station is now being enlarged to its full capacity. Fuller particulars of this condensing water arrangement will be found in our earlier description, to which we have already referred. The station is equipped with two 15,000 kw. turbo-alternators supplied by the British Thomson-Houston Company, Limited, of Rugby, and two machines of similar capacity supplied by the General Electric Company, Limited, of Birmingham. The three further sets which will complete the station are also being supplied by the General Electric Company. One of them is now in course of erection in the station, and the other two were to be seen in process of manufacture in the works of the General Electric Company at Witton, which were visited on Tuesday afternoon, and to which we will refer more in detail later. The turbine-room of Nechells station, even with its present capacity, makes a very striking picture, as may partly be gathered from the general view given in Fig. 1, annexed. When the station is completed with its seven sets of uniform capacity the effect should be unusually fine.

The most recent development at Nechells and one of particular interest, is the powdered-fuel installation, which has been installed to operate in connection with the last six boilers. This installation, which has been made by Messrs. International Combustion, Limited, of Africa House, Kingsway, W.C.2, is nearing completion, and the first two boilers had been put into operation for the inspection of Tuesday last. The boilers to which the plant is applied, were built by the Vickers-Spearing Boiler Company, Limited, and each have 5,400 sq. ft. of heating surface. They are being fitted with radiant type superheaters, water-screen walls, steel tube economisers and two air preheaters. Steam is generated at 320 lb. per square inch pressure superheated to 700 deg. F. Each boiler has a normal evaporation of 35,000 lb. per hour, and an overload capacity of 42,000 lb. per hour. It is of much interest to note, as bearing on the development of the large capacity boiler in this country, that for the final boiler-house extension it is proposed to instal four boilers, each of an evaporative capacity of 150,000 lb. of water per hour, and fired with pulverised fuel.

The present pulverised fuel plant consists of four raw coal bunkers, four rotary steam driers, four Raymond pulverisers, two pulverised coal bunkers and two Fuller Kenyon pulverised fuel pumps. The plant is situated in a pulverising house on the opposite side of the canal from the power-house. The bunkers are fed from barges by overhead electric telphers, the coal, as it is received, being the same as that used for the older boiler plant, and containing from 12 to 20 per cent. of total moisture. It has a calorific value when dry of from 10,000 to 10,700 B.Th.U. per lb. The bunkers are fitted with chutes which feed the driers. These are of the rotary steam-heated type, vapour formed being carried off by hot air circulated by a fan which discharges into a cyclone separator. This traps and returns to the system any coal dust picked up by the hot air. A magnetic separator is incorporated in this plant to remove any tramp iron and steel and prevent it passing to the mills.

The four Raymond pulverisers are of the six-roller type, and are each capable of pulverising 6 tons of coal an hour to a fineness such that 85 per cent. will pass a 200 mesh, 95 per cent. a 100 mesh, and all will pass a 40-mesh sieve. Separation of the pulverised fuel and elevation to the storage bunkers is effected by a current of air circulated in a duct system by an exhauster fan. The air enters the base of the pulveriser, picks up the coal, and discharges into a cyclone separator situated above the level of the pulverised coal bunkers. The powdered coal, thrown out in the cyclone, passes through an automatic flap valve into the bunkers, and the air returns to the base of the pulveriser for re-circulation. The arrangement forms a closed system and there is no dust nuisance. An automatic relief valve is fitted to guard against the building up of pressure.

FIG. 1. INTERIOR OF NECHELLS POWER STATION.

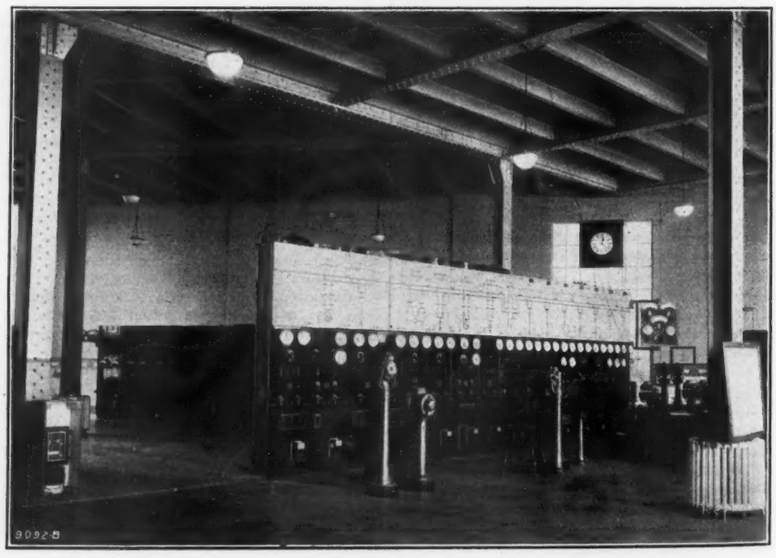


FIG. 2. CONTROL-ROOM AT NECHELLS POWER STATION.

The pulveriser house, as already explained, is on the opposite side of the canal from the power station, the distance separating the two being about 120 ft. Conveyance of the pulverised coal to the boiler house bins is effected by the two electrically-driven Fuller Kenyon pumps already referred to. These pumps consist of a screw conveyor arrangement acting in conjunction with an air compressing plant, which normally supplies air at 40 lb. per square inch. This apparatus propels the fuel to the boiler house through pipes 5 in. in diameter and of a total length of 270 ft., the run involving a lift of 60 ft. The air pressure can be increased to clear any block which may occur. Over each boiler there is a pulverised fuel bin, and by means of a series of electric-pneumatic valves, operated by push buttons in the pulveriser house, any bin may be filled at will. The pulverised fuel feeding gear, the burners and the boiler combustion chambers are of the well-known Lopulco type. Each bin terminates in a hopper, to the bottom of which are attached four fuel feeders grouped in pairs. The feeders are of the screw type, the fuel falling in to the screws by gravity and being propelled downwards towards the discharge end of the feeder, where it meets the primary air. The air and fuel are effectively mixed by a rotating paddle. The primary air, which constitutes about 15 per cent. of the total air required for combustion, is supplied at a pressure of 16 in. water gauge. The screw feeders are

driven by variable speed electric motors with a speed range of 3 to 1, so that the arrangement may easily be adapted to different conditions of steaming.

Each furnace is equipped with four burners located in the arch and discharging downwards. They produce a flat divergent stream of fuel, and are kept cool by a current of cold air induced through damper controlled passages. The furnace is of the steel-cased type with hollow walls through which the secondary air circulates before entering the furnaces. The furnace arch is of the Liptak flat suspended type, while the furnaces are constructed with a water-screen and water-cooled back wall. The screens and back wall form an integral part of the boiler circulating system, and, while serving to prevent fusing of the ash and slagging of the brickwork, add materially to the evaporation of the boiler. The secondary air enters the furnace through 84 ports located in the front wall and arranged in groups controlled by independent dampers.

Before leaving this brief account of some of the latest features of the Nechells station some reference should be made to the switchgear, since, as will be clear, when this station becomes one of three of the bulk stations of the area, this gear will form a very important control point, as indeed it does at present. The early part of the station was equipped with Reyrolle gear, as was fully described and illustrated in our earlier articles. Later extensions have been made with gear built by the General Electric Company, Limited. The bus-bars in this case embody a very interesting departure in the details of high-tension switchgear construction since porcelain insulators have been entirely eliminated, and the bars are completely encased in micanite tubes and carried on bakelite pillars. It is claimed that this construction has many of the advantages of compound encased gear, and at the same time retains many of the different advantages of cellular gear. A view of the present switch control room is given in Fig. 2 opposite. A final point of some interest in reference to this station may be mentioned. It generates at 5,500 volts and 25 cycles. Neither of these is, of course, in line with the modern standards of the country, and some consideration is being given to the possibility of changing over to the 6,600 volt and 50 cycle standards. The periodicity is obviously the more important matter of the two as the voltage of generation is more or less a domestic matter, but the cycles persist through the whole of the alternating-current distribution. The unsuitability of this periodicity for much of the domestic load has been met by employing direct-current distribution through arc-rectifier substations as described in a recent paper read before the Institution of Electrical Engineers, and reprinted by us in our issues of December 5 and 19, 1924. None the less it is probable that the heavy expense and trouble of changing over the whole system to 50 periods will sooner or later have to be faced. The taking in hand of the new Hams Hall station will probably give as good an opportunity as is ever likely to arise.

(To be continued.)

LAUNCH OF S.S. "SHIRLEY G. TAYLOR."—Built to the order of the Eastern Steamship Co., Limited, of Canada, by Earle's Shipbuilding and Engineering Co., Limited, and intended for trading on the Great Lakes, the S.S. Shirley G. Taylor was recently launched at Hull. The vessel is 253 ft. in length between perpendiculars, and has a moulded breadth of 43 ft. and a moulded depth of 20 ft. The deadweight capacity is 2,510 tons. The propelling machinery, which is to be placed well aft to obtain the maximum length of holds, will consist of a set of triple expansion surface condensing engines, having cylinders 17, 28 and 46 in. in diameter with a stroke of 33 in. Steam will be supplied by two main boilers each 12 ft. internal diameter and 11 ft. in length, working at a pressure of 180 lb. per square inch. These boilers are being fitted by the builders. A speed of 11 knots is anticipated by the builders of the ship. The hull has a cellular double bottom running fore and aft, which carries water ballast, while the two peaks are arranged for the same object. The vessel will be completed to the requirements of the British Corporation Rules for steamers trading on the Great Lakes of Canada and River St. Lawrence, and in accordance with the Board of Trade requirements for cargo steamers. Satisfactory trials were carried out recently on the completed S.S. Judge Kenefick, a sister ship of the above described vessel.

THE LATE MR. E. F. SPURRELL.

THE regretted death occurred on June 3, after a brief illness, of Mr. E. F. Spurrell, Borough Engineer to the Metropolitan Borough Council of Holborn. Mr. Spurrell commenced his career in 1881 as an assistant at the St. Giles' Board of Works, and when the district was merged with that of Holborn to form the new Metropolitan Borough in 1900 he was appointed Deputy Borough Surveyor. He succeeded Mr. Wallace as Borough Surveyor in 1905. Mr. E. F. Spurrell who was 56 years of age, rendered valuable service for over forty years with the same authorities, in the course of which period he was responsible for many improvements in the amenities of the Bloomsbury area of London. His work in Holborn was naturally influenced by the fact that the Borough had long been completely built over, and therefore reconstruction and modification of existing buildings only were possible. Under Mr. Spurrell's guidance notable improvements in the drainage of the locality were carried out, whilst the British Museum Avenue and Woburn Place testify to his skill in road-making. He was associated with the construction of Kingsway and Southampton-row, both of which operations entailed much responsibility.

The late Borough Surveyor was also employed on the work undertaken at St. Giles' Circus, when the Charing Cross, Euston and Hampstead tube was being driven. The area here, on which five roads converge, was excavated in order to install booking offices and lifts to serve the underground railway route. These operations involved the diverting of gas and water pipes, sewers, and electric light cables, tasks capably executed by Mr. Spurrell. Mr. Spurrell was a member of the Society of Engineers and of the Institution of Municipal and County Engineers, and for the past five years held the post of Hon. Secretary of the Metropolitan District to the latter Institution. Probably his greatest activity in such spheres of work, however, was the founding of the Institution of Public Lighting Engineers in 1923. He was a member of the Council of this organisation, which, as in the case of the Metropolitan Borough Council of Holborn, loses an energetic and capable official.

A BALL AND TUBE FLOW-METER.

AT a meeting of the Royal Society of Edinburgh, held on June 8 last, Sir Alfred Ewing described an apparatus for indicating the flow of liquids, which he had first devised about fifty years ago, while a student in the Physical Laboratory of the University. He had recently revived it in connection with experiments which were now being carried out by the Engineering Committee of the Food Investigation Board, and he had now made a much fuller investigation of its action. The purpose of the device is to provide a visible measure of the rate of flow of a liquid through any pipe system without interfering with the flow. It consists of a slightly tapered, straight, glass tube to which a scale is attached. Within the tube is a ball which is a loose fit at the bottom, and round which there is a considerable clearance as the ball is forced up in the tube. A steel ball of the kind used in ball bearings is suitable. The tube is placed in a sloping position with the narrow end down, and the liquid flows up towards the wider end. The stream carries the ball up along the tube until a position is reached where the clearance round the ball is such as to suit the particular rate of flow. When the flow is increased the ball moves to a higher position in the tube; when it is reduced the ball moves to a lower position. The position of the ball is read off on the scale, and from that position the rate of flow is determined. In the original experiments the tube had been placed vertically, but it was found that the ball was then liable to a certain instability and might be set vibrating, with the result that its position on the scale was affected. To avoid such instability the tube was fixed at a moderate slope, preferably about 30 deg. to the horizontal.

The sustaining action is partly an inertia effect due to the development of turbulence in the region above the ball, and partly an effect of viscosity by which the stream produces an upward drag in passing over the ball. The inertia effect was exhibited by the streamline method of Osborne Reynolds, a filament of coloured liquid being introduced in the lower part of the tube. This demonstrated that streamline motion was maintained up to the ball, but, after the acceleration in the narrows, turbulent motion showed itself a little way above the ball. The scale range of the instrument can be greatly increased by having in the tube a succession of two or more balls of different sizes so selected that when one ball approaches the upper end of the tube a smaller ball below it takes up the duty of indicating the flow.

EQUIPMENT FOR SALVAGE WORK AT SCAPA FLOW.

WE have referred at intervals to the successful work accomplished at Scapa Flow by Messrs. Cox and Danks, Limited, of 168, Regent Street, London, W., in salving the various ships of the scuttled ex-German fleet. The twelfth torpedo-boat destroyer, S.56, which was one of those lying on its side, was raised on the afternoon of June 5. From the time that the floating docks were brought into position beside the vessel, four days only were needed to put it into an upright position, lift it and tow it to the base at Mill Bay, a distance of four miles. The vessels presenting the least difficulty in salvage were raised first, and as the work proceeds further provision of equipment becomes necessary. For this reason the company has now purchased from the Admiralty the large ex-German floating dock No. 23, which has been lying for some time at Chatham. This is one of the largest constructions of its type in the world, and its lifting capacity is 40,000 tons. It is a sister to the dock which recently set out upon a voyage to Malta to be put into commission for the Admiralty. We are informed by Messrs. Cox and Danks, Limited, that their dock, which is built up of six separate sections and has an overall length of 703 ft. and a breadth of 194 ft., is to be broken up at Queenborough, where they recently dismantled the two Dreadnoughts Erin and Orion. One section will be towed 700 miles to Scapa Flow and put into service in raising the larger ex-German ships, while the breaking up of the other sections will provide employment for a large number of workmen during the next six months.

CARBONISATION OF LIGNITES IN CANADA.

EXPERIMENTS on the carbonisation of the lignites of Saskatchewan and Alberta have, since 1918, been the subject of reports from the Mines Branch of the Canada Department of Mines. The latest report on "Investigations of Fuels and Fuel Testing," No. 618 of the series, deals with the experiments of 1923. The brown Saskatchewan lignites, containing about 30 per cent. of moisture as mined, are used locally for household purposes and steam-raising and can be shipped and stored under cover. The black lignites of Alberta, to the carbonisation of which this report is confined, are, in their higher grades, with 10 per cent. to 15 per cent. of moisture, storage coals, and are sometimes also called sub-bituminous coals; the Report maintains this distinction, though the chief difference for the miner seems to be that the Alberta sub-bituminous coal is found in pitched seams, and the lignites are mined from flat seams. Both these Alberta coals are high in oxygen, burn with little white or bluish smoke like peat, and are known as household coals.

The low-temperature carbonisation experiments were made with samples of 3 kg. in an electric furnace with lead-bath temperature control, reaching the maximum temperature of 600 deg. C. in about four and a half hours. For high-temperature runs with samples of 2 kg., retorts were used, iron pipes 5 in. diameter, 10 in. long, being heated up to 950 deg. C. The calorific value of the black lignites is about 11,500 B.Th.U.; that of the sub-bituminous coal 12,500 B.Th.U., on the dry basis. The coals actually tested ranged in moisture from 21·4 per cent. down to 6·7 per cent. after transport or storage under cover. Both the lignites and the sub-bituminous coals yield incoherent "char" residues. When true bituminous coals are coked, the coke burns with less smoke, but calorifically it may or may not be improved on the weight basis. The Alberta coals showed us improvement as regards smoke, but the calorific values of the chars were decidedly higher than those of the raw materials; in the three lignites tested this increase ranged, on the dry basis, from 15·5 per cent. down to 8·5 per cent., in the two sub-bituminous coals it was about 6 per cent. The yields of char were, in the two classes, about 60 per cent. and 70 per cent.; the medium-grade lignite, giving 58·4 per cent. of char at low temperature, yielded 55·8 per cent. at high temperature. As regards gas, the lignites gave more gas at low temperatures (about 5,000 cub. ft. per 2,000 lb. of coal) than the sub-bituminous coals (3,100 cub. ft.), but these relations were reversed (8,800 cub. ft. and 10,000 cub. ft.) at high temperature. The tar yields were at low temperature 3·3, 6·2, 6·3 imperial gallons for the lignites, and 9·9 and 8·6 gallons for the coals; the figures at high temperature were 4 and 5 gallons.

Considering that these yields will hardly be realisable on commercial lines, and are low by comparison with the tar yields of the low-temperature carbonisation of peat (14 gallons, air dried) and of Illinois and English bituminous coal (15 per cent. and 22 per cent.), the tar-oil production by this carbonisation is not regarded as important. Briquetting tests of the carbonisation residues have not yet been made, but are to be taken up.

LABOUR NOTES.

REPRESENTATIVES of the executives of the engineering trade unions are to meet in London on June 19 for the purpose of considering the further communication which has been received from the Engineering and Allied Employers' National Federation. As was indicated in our issue of last week, the employers have intimated that any advance of wages without compensatory conditions is impracticable. They, therefore, in effect, extend another invitation to the unions to meet them in conference for the purpose of discussing the proposals which they submitted in April for the consideration of the men's representatives. Up till now, the unions have declined to consider the state of the industry, and have pressed for an unconditional offer on the wages question. The question of wages and the question of the economic state of the industry cannot, however, be discussed separately, for the one is determined by the other. On the facts and figures submitted by Sir Allan Smith before the wages question emerged, the industry clearly could not stand any addition to its manufacturing costs, and, largely because the unions have allowed things to drift, it is still less able to stand one now. Moreover, the longer the unions hesitate to face the real issue the worse must the position become. At present, British engineering firms cannot compete with firms abroad which, with the consent of the unions to which their employees belong, are working longer hours, paying lower wages and enjoying much more favourable working conditions. With that very serious state of matters the employers' proposals seek to deal, and the community will be greatly disappointed if at next Friday's conference co-operation is declined.

As was generally expected, the new industrial alliance proposed by the Miners' Federation did not find many enthusiastic adherents amongst the trade union representatives who were called to discuss it at the Midland Hotel on Thursday last week. After a number of speeches had been delivered, it was resolved to appoint a committee to examine the plan, but no obligation was put on the unions represented to appoint members. The following official report was issued after the meeting :—

"Mr. Herbert Smith, President of the Miners' Federation, presided. He welcomed, on behalf of his executive, representatives of other unions and expressed his appreciation at the response to the invitation of the Miners' Federation to consider a matter of vital importance to the organised workers. He explained that the object of the conference was to consider ways and means whereby, if possible, a scheme could be evolved for the mutual protection of all the industries represented at the conference. Various speakers addressed the conference and, as a result of the deliberations, the following resolution, proposed by Mr. J. T. Brownlie, President of the Amalgamated Engineering Union, and seconded by Mr. Frank Varley, M.P., of the Miners' Federation, was carried: 'That, in the opinion of this Conference, having regard to the present industrial situation and the community of interests that must necessarily prevail amongst the organised workers, the furtherance of this movement could be best served by the appointment of a committee to consider the suggestions submitted to the conference, and that each group of industries appoint two representatives to serve on that committee, their names to be submitted to Mr. Cook.'"

For an obvious reason, the conference could not come to a more definite decision on such a matter. Executive councils cannot bind their organisations to projects of this character without the authority of ballot votes, and ballot votes can only be taken on schemes which have been worked out in detail. A principle could, of course, be ballotted on, but in this instance the only straight question that could have been put was: If the miners strike, will you strike in support of them? Nobody in the conference had the power to answer that question one way or the other for his union; ballots would have been necessary. Some of the delegates are understood to have suggested that the General Council has power to co-ordinate the activities of unions in circumstances like those which prevail. Those who did so, however, were on very delicate ground, for there are highly placed and most experienced officials who incline to the view that nothing done by the General Council—nothing done even by Congress itself—can bind an affiliated union which has not previously decided the matter according to its own constitution.

The convention concerning equality of treatment for national and foreign workers under workmen's compensation for accidents schemes, which was provisionally adopted by the sixth session last year, was adopted unanimously by the International Labour Office at Geneva on June 5. Each member of the International Labour Organisation which ratifies the convention undertakes to grant workers who are nationals of any other member, which shall have ratified the convention, and who suffer personal injury through an industrial accident happening in its territory, or to the representatives of such workers the same treatment in respect of workmen's compensation as it grants to its own nationals. States which ratify the convention, and which do not already possess a system, whether by insurance or otherwise, of workmen's compensation for accidents agree to institute such system within three years from the date of ratification.

In the report of the Associated Blacksmiths' Forge and Smithy Workers' Society for the first quarter of the current year, Mr. William Lorimer, the general secretary, states that the improvement in trade in the previous quarter, as reflected by the number of members returned unemployed, was not maintained. At the close of March there were 1,689 on the books—an increase of 106—equal to 15 per cent. of the membership. The increase is ascribed to a further shrinkage of the volume of employment available in shipbuilding and marine engineering centres. At the end of the quarter the membership was 11,289, a reduction of 478. The total income for the quarter amounted to 23,107*l.* 7*s.*, which included 15,084*l.* 12*s.* 4*d.* received from the Ministry of Labour, and 1,935*l.* 0*s.* 2*d.* received from the Board of Health. The income from contributions amounted to 5,278*l.* 1*s.* 3*d.*, an increase of 466*l.* 8*s.* 5*d.* The total expenditure amounted to 23,099*l.* 4*s.* 9*d.*, which included 14,508*l.* 4*s.* 4*d.* for State Unemployment Dependants' Benefit and Administration Expenses, and 1,931*l.* 11*s.* 1*d.* for Health Insurance and Administration. The actual assets of the society stood at the end of the quarter at 8,905*l.* 5*s.* 1*d.*, a gain of 57*l.* 15*s.*

The official report of one of the craft unions states that the Railway Companies Staff Conference has submitted proposals for the setting up of machinery for adjusting questions of rates of wages, hours and general conditions of employment, and that the Engineering and Shipbuilding Trades Federation is pressing the companies' representatives to meet it for the purpose of discussing them. The difficulty is said to be that the companies insist on all unions having members in the workshops being parties to the procedure outlined, while some of the unions declare that joint negotiations with the National Union of Railwaymen is impossible until the latter relinquishes its claim to organise craftsmen. The Railway Staff Conference's proposals are as follows :—

(1) The object of the scheme is to afford full facilities for the discussion and settlement of all questions relating to the rates of pay, hours of duty, and general conditions of employment (other than matters of management and discipline) of adult male wages staff employed by the railway companies of Great Britain signatories hereto under shop conditions on constructional repair and maintenance work.

(2) The main principles on which the scheme is based are (*a*) direct application from the employees concerned to the management of the company in all matters within the scope of the scheme, other than those of a national character; (*b*) the establishment of shop and works committees and departmental line committees where there are no shop committees, consisting of nominees of the company and elected representatives of the employees, for the purpose of dealing with all questions within the scheme that may be referred to them; (*c*) direct negotiations between the headquarters of the trade unions and the general manager of the railway company on matters which cannot be settled between the staff concerned and the head of department or his representative; (*d*) negotiations between the railway staff conference and the trade unions with regard to questions of pay, hours of duty, and general conditions of employment within the scope of the schemes, which are of a national character; (*e*) if the parties fail to agree but are prepared to submit the matter in dispute to arbitration the reference to be to the Industrial Court.

With a view to composing the differences of the unions interested, the General Council of the Trade Unions Congress has submitted the following for the consideration of the various executives :—

(1) That the membership of the unions catering for shopmen should be regarded as inviolate, and that no member of a union engaged as a railway shopman should be admitted to membership in any other union until his former union has been consulted and all dues met. Further, the membership application form of all the unions concerned should contain an inquiry to be answered by the applicant as to whether he is, or has been, a member of any other union, and, if so, what his financial relationship is to that union.

(2) A full committee shall endeavour to secure unification of contribution of each of the unions participating in these negotiations in so far as trade benefits are concerned.

(3) Craftsmen employed in railway workshops who have not hitherto been members of any of the trades unions concerned shall have freedom of choice as to the unions which they join.

(4) It is advisable that all national negotiations affecting the interests of railway shopmen shall be conducted jointly. With respect to purely craft questions, each individual union shall have the right of separate negotiations.

The first of the reports of the Select Committee on Estimates deals with the figures for the Ministry of Labour. It states that the gross estimate for the year 1925–26 is 19,403,223*l.*, showing an increase of 923,446*l.* over the figure of 1922–23. The bulk of the expenses were incurred in administering unemployment insurance, no less than 90 per cent. of the Employment Exchange services being on account of unemployment insurance. The staff of the Ministry for the current year is 15,047—an increase of nearly 10,000 compared with 1917, but a reduction of about 350 on the figures for the previous year. Of the total staff about 45 per cent. represent permanent staff. The Committee say it would conduce to economy and efficiency if this proportion could be increased and the temporary staff diminished.

The committee were impressed, it is stated, by the large expenditure on the Statistics Department of the Ministry, a staff of 184 being maintained at a cost of 65,213*l.* They accordingly personally inspected the department, and came to the conclusion that the expense is considerably enhanced by the distribution of work in different buildings, and recommend that the question of concentration of staff should be promptly and seriously considered. They call attention also to "the unsuitable and in many cases costly sites" occupied by labour exchanges. "Neither in the interests of the unemployed, nor in that of the ordinary trade of a town, least of all in that of public economy," it is remarked, "is it desirable that labour exchanges should occupy prominent positions in main commercial thoroughfares." The committee suggest the disposal of costly offices now in use and the selection of less costly and more appropriate positions.

The committee also point out that Great Britain, although contributing 9·41 per cent. of the expense of the International Labour Office at Geneva, has only one vote out of 54. They are of opinion that in this matter taxation ought to correspond with representation.

One of the resolutions put down for discussion at the annual conference of the Labour Party at Liverpool in September proposes the setting up of a National Employment and Development Board on the lines of the organisation which was recently the subject of an unsuccessful Bill in Parliament. The Board is to be representative of all State departments concerned with employment and natural resources. It is to inquire into the nature and remedies for unemployment, "to prepare schemes of national development, including schemes for the better utilisation and development of the land, transport, mines and electrical undertakings, and to encourage the preparation of schemes of development in other parts of the British Commonwealth." It is also to have power to arrange for the postponement or acceleration of Government contracts and public works in order to redress the balance of employment. Maintenance of the unemployed is retained at rates "adequate for healthy sustenance." The details of the party's unemployment proposals are to be put before the country in the course of a campaign which is being organised by the General Council of the Trade Unions Congress and the National Unemployed Workers' Committee. On June 21 there will be demonstrations in 29 centres. The resolution to be submitted declares for the policy of the Labour Party's Bill and proposes that unemployment benefit shall be 30*s.* a week, with 10*s.* for a wife and 5*s.* for each child.

The Ministry of Labour states that on June 1, 1925, the number of unemployed persons on the registers of Employment Exchanges in Great Britain was 1,247,300, or 971,200 men, 34,200 boys, 213,800 women, and 28,100 girls. On May 25, 1925, the number was 1,186,522, viz., 925,506 men, 32,947 boys, 199,797 women and 28,272 girls: and on June 2, 1924, it was 1,002,915—754,661 men, 31,961 boys, 185,731 women, and 30,562 girls.

BUCKET DREDGE FOR ALLUVIAL GOLD: ERRATUM.—We regret that in the article on the above subject, on page 699 *ante*, Mr. A. R. Brown's address was inadvertently given as 54, New Bond-street, instead of New Broad-street, E.C. 2.

MISCELLANEOUS APPLICATIONS OF THE PLATE-EDGE PLANER.

IN a general engineering works, the plate-edge planer is usually a machine which stands idle for long periods, alternating with short spells of activity. The utility of such a machine in a constructional works is well known, and, given an operator with a fair measure of ingenuity and a judgment based on skill at the craft, the plate-edge planer in the general works should usually do more towards paying the rent of the floor space on which it stands. Of course, when the machine is not being used for plate planing, the table may be used in other ways. It is planed on the surface, thus making it serviceable as a marking out bench for many articles; it also contains a great number of holes, some of which can be used for clamping bolts as in the case of flanging thin plates. It is not suggested that anything above ¼ in. plating should be flanged on a planer table; nor is it recommended that the edge beneath the pressure beam should be used for flanging on—as one might feel inclined to do owing to the screw-jacks being handy for the purpose of clamping—because of the damage which is likely to occur to the slides or the screw, by the swinging of the hammer near to them.

The object of this article is not, however, to enumerate the various uses to which the table can be put, but to suggest profitable methods of employment of the machine as a plate planer, and also to describe in detail some jobs that may be found for the machine, which would at times relieve the other planers or shapers, as the case may be. Much depends upon the skill of the operator, in addition to his ingenuity, but the suggestions and possibilities mentioned here are quite within the range of a man when he has behind him a superior who is prepared to take some risks with the machine to find its full capabilities. It must be admitted that some jobs are of the nature of experiments, and it is useless to attempt such experiments unless the skill of the operator is adequate. The power of the machine in relation to the work to be attempted is also a factor to be considered.

When a number of thin plates require to be made to one size, advantage may be taken of the capacity of the machine to resort to multiple planing, and should the specification of the machine give 1½ in. as the maximum thickness to be planed, thin plates may be bundled to about 25 per cent. above that limit, and planed without risk of over-loading. The reason why this is possible is because a number of narrow shavings break away from the tool with much less resistance than one of full width; thus, the power taken to operate the cut on, say, six ¼-in. plates, will be much less than on one solid plate of equal thickness. This idea is most advantageously employed on plates that require planing on one edge (or side, as it is termed), or on two when squaring the corners, as with a batch of plates for steel wagons. Such plates can be planed to the net size very much more cheaply than it would cost to line out and shear them, as plates up to 5 ft. sq. by ¼ in. thick should not cost more than 1*d.* per side. The valuable features of planed edges show up in such subsequent operations as marking off for punching, or bundling for drilling the holes, and the assembling is far more accurate, while the finish leaves nothing to be desired.

Corner thinning is another job which can be done at less cost on the plate edge planer than at the fire. The method is unsuitable for pressure work, nevertheless there are many other instances such as hopper and chute work, gas-tubes that are to have a brick lining, steel chimneys, &c., for which this method is quite suitable. For this work a cutter-bar and surface planing tool, such as shown in Fig. 1, are necessary. The tool shown is double-ended, and with this both right and left-handed corners may be thinned; the tool can also be used for other purposes, as will be mentioned later. The method of thinning a corner is shown in Fig. 2; the tool is inserted in the cutter-bar, but the cut can be taken one way only, as will be noted. To fix the plate a packing piece or wedge of the same thickness as the plate to be machined, is placed beneath the corner to be thinned, as shown; the screw-jack is then lowered to clamp the plate to the table, and at the same time, to incline the corner, The packing piece must not lift the corner more than the thickness of the plate, and the cut must not be too heavy or the metal will perhaps break out at the holes when the operation is nearing completion. The corners of plates of ⅜-in. in thickness can be thinned in this way at a cost of 3*d.* per corner.

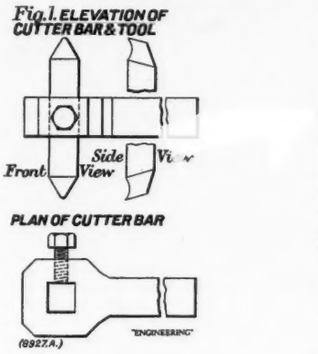
There are certainly some objections to other taper work being done on a plate planer: one is the amount of reversing necessary for the primary cuts, but the same may be said about the other type of planer on some of the jobs it has to do. Another objection is that the work is slightly inaccurate owing to the lift in the cutter bar, although this may be corrected sufficiently for such jobs as large wedge packers and taper bearing plates. The latter objection will also apply to surface planing with a plate-edge machine, but such planing is done in constructional works, and as previously stated, much depends upon the operator of the machine. The costs compare favourably with those of work done on an ordinary planer, so the class and amount of work on hand must be the deciding factor as to which machine shall do the job.

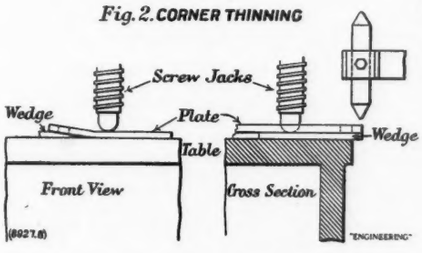
Of course when surface planing is being done on a plate planer the overhead pressure beam and screw-jacks are of no avail; clamping is effected by means of bolts and washer-plates, the work being secured to the table of the machine by the latter and held in position by pegs and packing pieces firmly fixed around the sides.

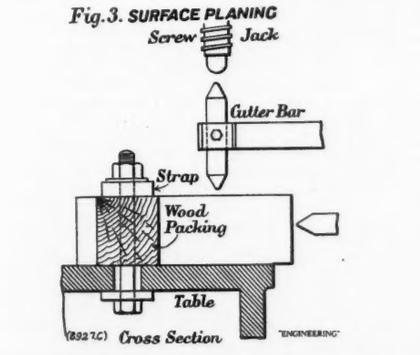
Fig. 3 illustrates the method of clamping, and it also shows the application of the tool which is used for "skimming" the faces of block-like articles that will pass beneath the pressure beam. In no instance of this class of work must the plate-edge planing tool be used or disaster will occur. When circumstances warrant the cost, special tools may be made for bevelling or radiusing; examples of suitable forms are shown in Fig. 4. On this class of work the advantage which the plate-edge planer offers is that the cut can be taken in both directions. Mechanical traversing is out of the question, but as the operator is carried along on a platform attached to the saddle, hand traversing and foot reversing on modern machines is a simple matter. The advantage of this mechanism is that the attention of the operator is concentrated on his work, and one might almost say that in these circumstances a job never stays on the machine a moment longer than is absolutely necessary.

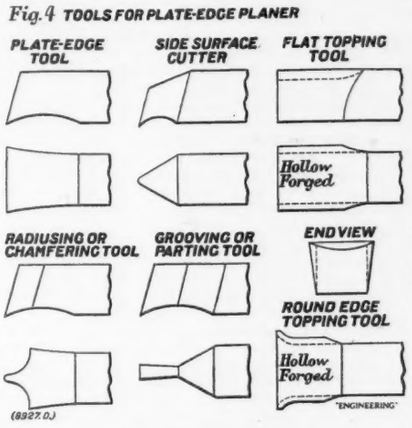
The reducing of sections is a job which can be accomplished cheaply on the plate-edge planer: rolled steel joists may be converted into channel or tee sections and channels into giant angles, or the fins of any section may be reduced. In Fig. 5 the method of rounding the heel of an angle is illustrated; a chamfering or radiusing tool is used for this purpose, and the cut can be taken in both directions. It will be noted that a packing strip is inserted between the angle and the table, this is to allow the root of the angle to clear the square edge of the table. Fig. 6 shows how joist and channel sections may be fixed in the machine when it is required to reduce the flanges. If the same tool as that shown for rounding the heel of an angle (Fig. 5) is used for this purpose the finish will be similar to the original rolled edges; for a square edge the ordinary plate-edge tool must be used. When a section is too deep to stand beneath the pressure beam, or when a fin has to be completely removed, the method shown in Fig. 7 (page 746) may be employed. In this case the parting tool is the one to use for separating the fin from the web, but to put a finish on the job the topping tool, as shown above the fin must make the final cut. The topping tool is also used for reducing the fin of a joist or channel section when a square edge is required, but a similar tool with grooves ground on the cutting edges may be employed to produce a finish similar to the original rolled edges.

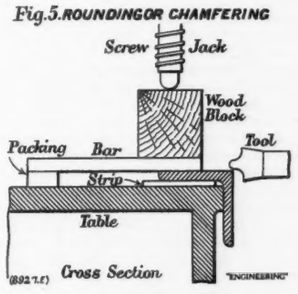
The parting of solid sections, or the cutting of deep grooves in thick mild steel bars, are jobs which a plate-edge planer can usually accomplish more cheaply than the other type of machine. It is not suggested that fine limit work can be done, for which the machine was never intended; therefore, this should not be attempted. The parting tool previously mentioned is quite satisfactory for thicknesses up to about ½ in.; beyond that there may be some trouble to get the tool to stand up to the work, owing to the excessive friction caused by the shavings when leaving the grooves. On an actual job, involving the parting of a number of thick steel bars, it was found that the ordinary parting tool failed because the friction of the shaving on the sides of the groove gradually became more than it could stand. Tool after tool in modified forms were tried, but all came to grief through the same cause. As is well known, a shaving which has been cut from

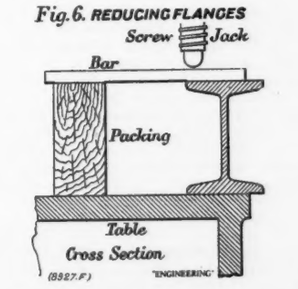






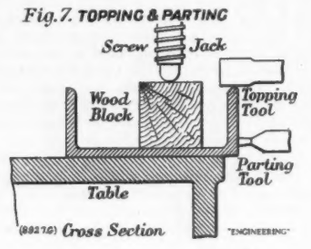


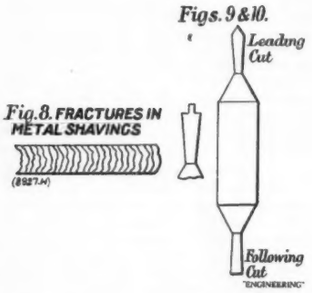




a piece of mild steel with a planing tool is broken up into small pieces in spite of the continuous curl that it assumes. The smooth side of the shaving presents an appearance similar to the lines in the sketch, Fig. 8, and the effect of this fracturing causes the strip which is being ploughed off to bulge, thus resulting in additional friction. With care a little better result was obtained by the use of a tool with a lead on the cutting face; in other words, the cutting edge was not square with the axis of the tool. The results, however, were not really satisfactory, and the problem was eventually solved by splitting the shaving into two parts. A tool as shown in Fig. 9 was tried. This proved successful in operation; the costs, however, were too high.

It was at this stage that the plate-edge planer was suggested as being probably of assistance in reducing the cost of operation. The operator's help was





enlisted, and soon a modification of a tool was put in hand for a trial at cutting in both directions on this machine. The strong cutter bar (of 1½-in. square steel) as shown in Fig. 1, was already in existence. The new tool was fashioned as shown in Fig. 10; this was placed centrally in the cutter bar and a trial was made. The first result was so satisfactory that the whole of the work on these bars was allocated to the plate-edge planer. There was no further difficulty, and as it was possible to reverse the tool by swinging over the tool-holder on the saddle of the machine, the task was quite simple. First the V-end of the tool cut a groove along the centre line as the carriage travelled outwards; then on its return the correct width of the groove was formed by the flat cutting edge ploughing out the two sides. The V-end of the tool is capable of being improved in design, but against that must be set the extra cost of forming; as it is, the cutting edges are no trouble to form on the universal grinder. In conclusion it may be said that all the work here mentioned as being possible on the plate-edge planer, has actually been done. In addition to this such work as the skimming and modifying of smith's bending blocks, levelling blocks, shaping blocks for hydraulic presses, and similar jobs, have for preference been allocated to this machine.

TRIAL TRIP OF THE STEAMER "NORTHGATE."—Recently the single-screw steamer Northgate, built by Messrs. R. and W. Hawthorn, Leslie and Co., Limited, at their Hebburn shipbuilding yard for Messrs. Pease and Partners, Limited, ran a successful trial trip off the mouth of the River Tyne. The vessel, which has been constructed to the requirements of Class 100 A.1 of Lloyd's Register, is 150 ft. in length, 25 ft. 2 in. in breadth, and 12 ft. 7 in. in depth, and has been specially designed for the transport of pig-iron and other high-gravity cargo between Stockton and British and Continental ports. The Northgate has a straight stem and elliptical stern, with a top-gallant forecastle bridge house and raised quarter-deck extending over the space occupied by the engine and boiler. An extensive hold is provided with a large hatch. This hold is served by derrick gear capable of handling a load up to 5 tons weight, while winches are supplied for the rapid manipulation of the cargo. The propelling machinery consists of a compound surface condensing engine, built by the Shields Engineering and Dry Dock Company, Limited. Steam is supplied by one single-ended cylindrical boiler.

INDIAN RAILWAYS, 1923-24.

"DURING the year 1923–24 the railways of India made solid progress towards recovery from the effects of the war period. Both as regards financial results and standard of efficiency, the year may be said to have marked the turning-point from a period of deficits and general inability to handle the trade of the country towards financial solvency, and the provision of transportation in some degree comparable to the demand." This quotation is from the opening remarks of the report by the Railway Board on the administration of Indian railways in 1923–24. The result of the year's work on the railway lines with which the Central Government are directly concerned showed a net profit of Rs. 647 lakhs, as against a profit of Rs. 1·22 crores in 1922–23, thus giving a net return of 5·24 per cent. on the capital at charge. The total earnings on these lines amounted to Rs. 9,489 lakhs, while expenditure totalled Rs. 8,841 lakhs. The total earnings on all lines including those owned by Native States, amounted to Rs. 10,780 lakhs. Of these earnings Rs. 3,809 lakhs, representing about 35 per cent., were derived from passenger traffic, while Rs. 6,064 lakhs, representing about 56 per cent., were derived from goods traffic. It is interesting to note that the increase in fares of the third-class passengers, has only had the effect of reducing slightly the progressive rate of increase in the number of passengers as compared with previous years. In the case of the goods traffic a rebate amounting to 25 per cent. of the actual freight rate, excluding terminal and extra charges, on export of coal and coke booked from collieries on the East Indian and Bengal-Nagpur Railways to Calcutta, was introduced from January 1, 1924, with a view to helping the Indian coal industry to regain its lost footing in the market.

The report mentions that the reduction of working expenditure was the main pre-occupation of the Agents of railways throughout the year. The working expenses of State railways decreased from Rs. 6,596 lakhs in 1922–23 to Rs. 6,105 lakhs in 1923–24, a reduction of Rs. 490 lakhs. This reduction is made up of Rs. 159 lakhs under programme revenue, Rs. 98 lakhs under fuel, Rs. 57 lakhs under the head maintenance and repairs of the track, buildings, rolling-stock and plant, and Rs. 180 lakhs under establishment charges and general operating expenses.

The distribution of the working expenditure was as follows: Engineering, 1,228 lakhs; locomotive, 2,173 lakhs; carriage and wagon, 799 lakhs; agency and others, 447 lakhs; miscellaneous, including ferry, law charges, compensation, contribution to provident fund, &c., 474 lakhs; and suspense, 19 lakhs.

The saving in expenditure under programme revenue was due to the fact that the method adopted by the Railway Board during the year for dealing with proposals for the renewal of the stock, was to require the Agent to prove, not only that the unit proposed to be renewed had reached the age of its normal useful life as determined on the basis of the recommendations of the Depreciation Fund Committee, and that the particular unit could no longer be run economically, but that the existing effective stock was not in excess of requirements. As regards compensation for goods lost, which has shown an increase in recent years the Railway Board conducted a special inquiry, with the result that considerable progress was made during the year in strengthening the watch and ward organisation on several railways, with consequent decline in amounts thus paid. Also in the matter of stores balances, orders were passed to reduce them to minimum proportions by special measures suggested for the purpose.

The total capital outlay on all railways during 1923–24 was Rs. 2,132 lakhs, out of which Rs. 1,971 lakhs were spent on State-owned railways. Of this latter figure, 1,720 lakhs were spent on open lines and 251 lakhs on new lines. A total mileage of 430 miles was opened during the year, and consisted of 253 miles of 5 ft. 6 in. gauge, 155 miles of 3 ft. 3⅜ in. gauge, and 22 miles of 2 ft. 6 in. and 2 ft. gauges. Lines under construction amounted to a total length of 759 miles, of which 426 miles were of 5 ft. 6 in. gauge, 308 miles were of 3 ft. 3⅜ in. gauge, and 25 miles of 2 ft. 6 in. and 2 ft. gauges. Among the more important new lines opened may be mentioned the Amda–Dongoaposi section of the Bengal Nagpur Railway, 47 miles long; the Kazipett–Pedapatti section of the Nizam's Guaranteed State Railways, also 47 miles long; Katakhal–Lalbazar section of the Assam Bengal Railway, 24 miles long; the Dholka–Koth Gaogad section of the B.B. and C.I. Railway, 11 miles long; the Moulmein–Mudon section of the Burma Railways, 15 miles long; and the Shahadakote–Dodapur section of the North-Western Railway, 22 miles long. Among the lines under construction, the more important are the Itarsi–Nagpur (Amla–Narkhed section), which when completed will be about 185 miles long and will considerably reduce the distance between Northern and Southern India, and of which a large part has been opened for traffic recently after the close of the year; the Villupuram–Trichinopolly Chord, 100 miles long, which will form an alternative route between Madras and Trichinopolly, relieving present congestion; the Hesla–Chandil line and the Talcher Coal-fields Railway, both of which will open up important coal-fields and form branches of the Bengal Nagpur Railway.

As has been mentioned above, much the greater part of the capital expenditure during the year was expended on open lines, in remodelling important stations and yards on all railways, building new stations, improving water arrangements, and providing other facilities for the travelling public.

The value of rolling stock purchased during 1923–24 amounted to Rs. 1,086 lakhs; 341 engines, 685 carriages, &c., and 12,775 goods vehicles were placed on the line during the year. The policy adopted is one of progressive standardisation as a continuous process. A permanent Standing Technical Committee has been formed to consider the co-ordination of requirements in respect of existing and future types of locomotives. The intention is that, after a general specification and diagram for each type and classes of a type have been prepared in India, working drawings should be prepared in England in consulation with the consulting engineers and manufacturers and, after a final scrutiny by the Locomotive Standards Committee, should be adopted as standard designs. Each administration requiring engines will, however, only be permitted to indent for not more than two or three of a type or class of a type, so that such engines can be thoroughly tried for at least two years. The experience of all administrations will then be carefully analysed by the committee, and any modifications agreed upon introduced in the standard design before bulk orders are placed.

Among the new types of rolling stock introduced during the year was the Mallet engine ordered from the Baldwin Locomotive Company of America for service on the Quetta district of the North Western Railway. A Garratt engine is also being obtained. These two engines will be tried on the same section, and the data obtained from their use should be a great interest.

As regards the introduction of an automatic buffer coupler on Indian railways, a special committee of technical experts was appointed to consider the report of the officer deputed to America in that connection. The advantages from the adoption of this type of coupler have been recognised, and it is estimated that the total cost of the scheme for such rolling stock as can be fitted with this coupler is about 465 lakhs of rupees. It is expected that the cost of conversion will be more than saved by a reduction in the cost of maintenance and in the capital cost.

The value of materials purchased by Indian railways in 1923–24, excluding coal, coke, &c., amounted to 2,706 lakhs, or a decrease of 380 lakhs from the previous year. Rolling stock accounted for 1,086 lakhs; tools and stores, 706 lakhs; permanent way, 588 lakhs; electric plant, 89 lakhs; building and station materials, 58 lakhs; bridge work, 82 lakhs; workshop machinery, 78 lakhs; and engineer's plant, 19 lakhs. Of the total stores purchased, those of indigenous origin were valued at 837 lakhs. The manufacture of rails in India is at present practically confined to the Tata Steel and Iron Company, but these works were able to produce only 70,000 tons out of 120,000 tons required during the year. The sleepers purchased were practically all of Indian material. A special committee has been further considering the question of sleeper supply from indigenous sources. As regards locomotives, in view of the uncertainty as to the extent of the demand for new locomotives in the future, the possibility of establishing a factory in India for locomotive manufacture on an economic basis appears to be remote.

The total quantity of coal consumed by the railways amounted to 6·2 million tons, of which 1·7 million tons were obtained from railway collieries.

THE HARDENING TEMPERATURE OF STEEL.—An investigation was recently undertaken by Automatic and Electric Furnaces, Limited, of Elecfurn Works, 173–175, Farringdon-road, London, E.C.1, makers of the Wild-Barfield electric furnaces, for the purpose of demonstrating that the correct hardening of steel does not depend on the quenching temperature alone, but is also governed by the rate at which the specimen is heated to that temperature. A piece of steel containing 1·4 per cent. of carbon and weighing 1½ lb., was placed in a furnace maintained at a temperature of 880 deg. C. In the space of 7½ minutes the critical point, determined by means of a magnetic indicator, was registered at 760 deg. C. Upon heating a similar piece of steel more slowly by using a furnace temperature of 750 deg. C., the critical point was only reached after 27 minutes, and occurred at a lower temperature, namely, 730 deg. C. The interdependence of time and temperature in the determination of the all-important critical points of steel is evidently a matter of considerable consequence and well worthy of the closest attention on the part of hardeners.

OIL-ENGINE-DRIVEN ELECTRIC LIGHTING SETS.

CONSTRUCTED BY THE ORION ENGINEERING COMPANY, LIMITED, ENGINEERS, LEEDS.

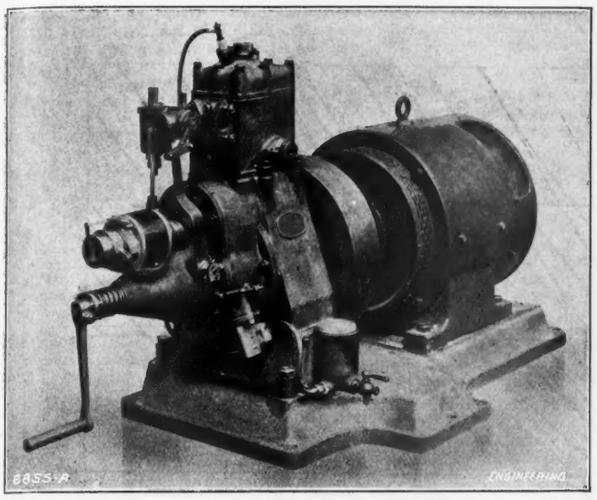


FIG. 1. 1½-KW. ELECTRIC LIGHTING SET.

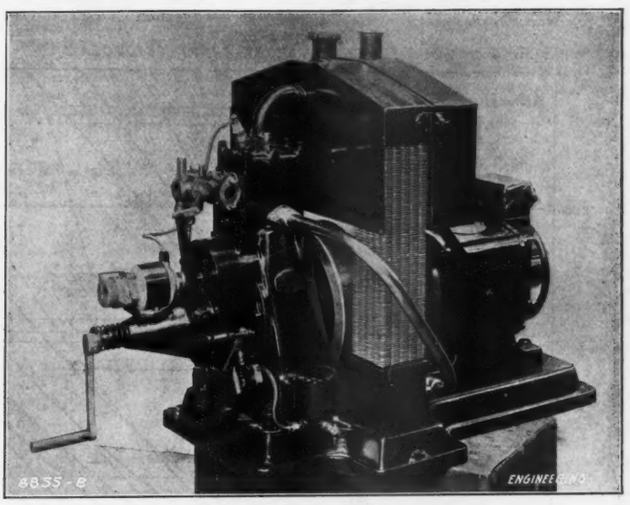


FIG. 2. ¾-KW. LIGHTING SET WITH RADIATOR.

ORION ELECTRIC LIGHTING SETS.

WHEN houses are remote from the distributing network of any electricity supply undertaking, the advantages of electric lighting can only be obtained by the installation of independent engine generator sets. For this purpose a small oil engine is the usual source of power, as the supply of fuel can be obtained in any district and can be conveniently stored. The engines are usually of an exceedingly simple design, requiring little skill for their operation, as they are frequently left to the care of persons with only limited knowledge of engineering plant. Fortunately, the people who are compelled to rely upon such engines for their electricity supply often have the services of a mechanic-driver for their motor-cars, and in these cases the engines are likely to be kept in a good running condition at all times. Naturally the demand for small complete sets is growing, and many firms which have experience in the construction of large oil engines have undertaken the manufacture of these miniature power plants.

The accompanying illustrations show two of the models made by the Orion Engineering Company, Limited, of Standard Buildings, Leeds, at their works in Aldbourne Road, Coventry. Actually three sizes, of 1½, 1 and ¾-kw. capacity, are made, and the illustrations show one of each of the largest and smallest powers. These engine sets all have single cylinders and work on the four-stroke cycle. They are of simple, straightforward design, and the control is effected by means of a crankshaft governor operating, through link gear, on the throttle valve. Practically all the parts are enclosed, but provision is made by which they are readily accessible for inspection or replacement. Though of very orthodox design, there are some features introduced into these engines to improve running and to reduce wear and tear. Roller bearings, for instance, are used in the connecting-rod big ends, but the main bearings are plain and made in phosphor-bronze. For the lubrication of the moving parts a double-acting oil pump is fitted. It is driven off the camshaft and supplies oil to the various parts through a trough within the crank-case. The oil is drawn from the sump through a filter outside the engine casting, and a drain is provided there to draw off the dirty oil when necessary. The accessibility of this part of the lubrication system and of the pump is obvious from the two illustrations. In cases where it is desired, any of the sets may be provided with radiators for cooling the jacket water, as is shown in Fig. 2, but water tanks may be used instead. By placing the radiator beside the flywheel, in the position shown in the illustration, little increase in the space occupied by the set is necessary, and it will be observed, from the views of both engines, that the standard bed-plates are made to accommodate the radiators in this way. A magneto is fitted for ignition purposes and is driven from the timing wheels. As all the parts of these engines are made with the use of jigs, they are completely interchangeable, and consequently there are no difficulties in making replacements. The generator is a simple type of direct-current machine wound to give a supply at one of a series of standard voltages.

GAS TURBINES.*

By M. KÖNIG, ING. DIPL., A.M.I.Mech.E.

THE position of the gas turbine relative to the gas engine is often considered to be analogous to that of the steam turbine to the steam engine. The enormous development of the steam turbine at the expense of the reciprocating steam engine during the last thirty years, raises the question of why a similar success has not been achieved by the gas turbine over the gas engine. The gas turbine certainly does offer definite advantages which justify its development.

Before discussing the theory and construction of this form of prime mover, a classification may be given of its various types, and of the working cycles employed.

CLASSIFICATION.

The classification of the gas turbine in many ways closely follows that of the steam turbine, except that with the gas turbine, there is a larger choice of possible cycles and fuels.

(A) *Classification According to the Nature of the Fuel Burnt.*

(1) Gas turbines proper. (Including hot-air and exhaust-gas turbines.)

(2) Oil turbines.

(3) Turbines working with powdered fuel. (Tried by Holzwarth with coal, and also proposed in numerous patents.)

(B) *Classification According to the Nature in which the Combustion takes place.*

(1) *Constant-Pressure Turbines.*—In a constant pressure turbine the chamber in which the gas is generated is always connected with the turbine, and the gas flows into the turbine continuously.

(2) *Explosion or Constant-Volume Turbines.*—The combustion chamber in this case is closed towards the nozzles during the combustion, so that the total volume remains unaltered, hence the name of constant-volume cycle.

(C) Gas turbines may be further sub-divided according to the manner in which the kinetic energy of the gases is utilised in the turbine proper, but at the present stage of development only the single-stage axial impulse turbine can be considered, as temperature and materials do not, for the time being, permit the realization of a multi-stage impulse or even a single stage reaction turbine.

THE CYCLES USED AND THEIR THERMAL ASPECTS.

(A) *The Entropy Chart.*

Symbols used :—

P = absolute pressure in kg./m².
V = specific volume in m³/kg.
R = gas constant in 1/m. ÷ °C.
T = absolute temperature = $273 + t$ °C.
m = molecular weight in kg.
n = number of kg. mol. of a certain gas in a gas mixture.
V = volume of one kg. mol. in m³.
c_p = specific heat at constant pressures for 1 kg.
C_p = specific heat at constant pressures for 1 kg. mol.
c_v = specific heat at constant volume for 1 kg.
C_v = " " " " 1 kg. mol.
a = constant.
A = mechanical heat equivalent = $\frac{1}{427}$.

The extreme usefulness of the so-called entropy chart for steam turbine calculations, has led to the introduction by Professor Stodola of the gas entropy chart for analysing the various cycles on which the gas turbine operates. This chart is shown in Fig. 4, and is based for convenience not on 1 kg., but on 1 kg. molecule (1 kg.-mol.). The advantage gained by the introduction of this unit lies in the fact that for any given pressure and temperature, one kg.-mol. of any gas has the same volume (24·35 cub. m. at a pressure of 1 kg. per square cubic metre and 15 deg. C.).

An example of a constant-pressure cycle is given in Fig. 1, based on the blast-furnace gas considered above. The point A represents the beginning of the cycle at atmospheric pressure, and a temperature of 27 deg. C. *i.e.*, 300 deg. C. absolute. Isothermal compression leads to the point B where the calorific value per kg. mol. (10,950 cals.) on being marked off, fixes the point C at the same pressure—whence adiabatic expansion brings the gas condition theoretically to D. From this point the initial conditions are again attained at A by cooling at constant pressure.

The theoretical thermal efficiency of this cycle may readily be obtained as follows :—

Theoretical Thermal efficiency.

$$\eta = \frac{H_p - (W_D - W_A)}{H_p} = 1 - \frac{W_D - W_A}{H_p}.$$

To arrive at the actual efficiency, the radiation loss in the combustion chamber and the efficiencies of the compressor and turbine have to be considered.

(B) *Thermal Aspect of Various Cycles.*

Once the use of the entropy chart is familiar, it is an easy matter to investigate the relative merits of the various cycles proposed.

(1) *Carnot Cycle.*—The Carnot cycle represents theoretically the ideal conversion of heat into work. A closer examination shows, however, that the isothermal compression calls for extremely high pressure ratios, which involve negative work of such a magnitude as to make this cycle unsuitable in practice with present-day means of compression.

The efficiency of the Carnot cycle :—

$$\eta \text{ thermal} = 1 - \frac{T_2}{T_1}$$

is only obtainable if the whole of the heat is added in the course of the cycle at constant temperature,

* Paper read before the N.E. Coast Institution of Engineers and Shipbuilders on April 24, 1925. Abridged.

and all the exhaust heat is taken out again at a constant lower temperature.

(2) *Constant-pressure cycle.*—The thermal aspect of a cycle is shown in the ratio of positive work to negative work. Using the symbol K for this ratio, it is evident that—

$$\frac{\text{Work of turbine}}{\text{Work of compressor}} = K = \frac{W_t}{W_c} = \frac{2356}{1056}$$

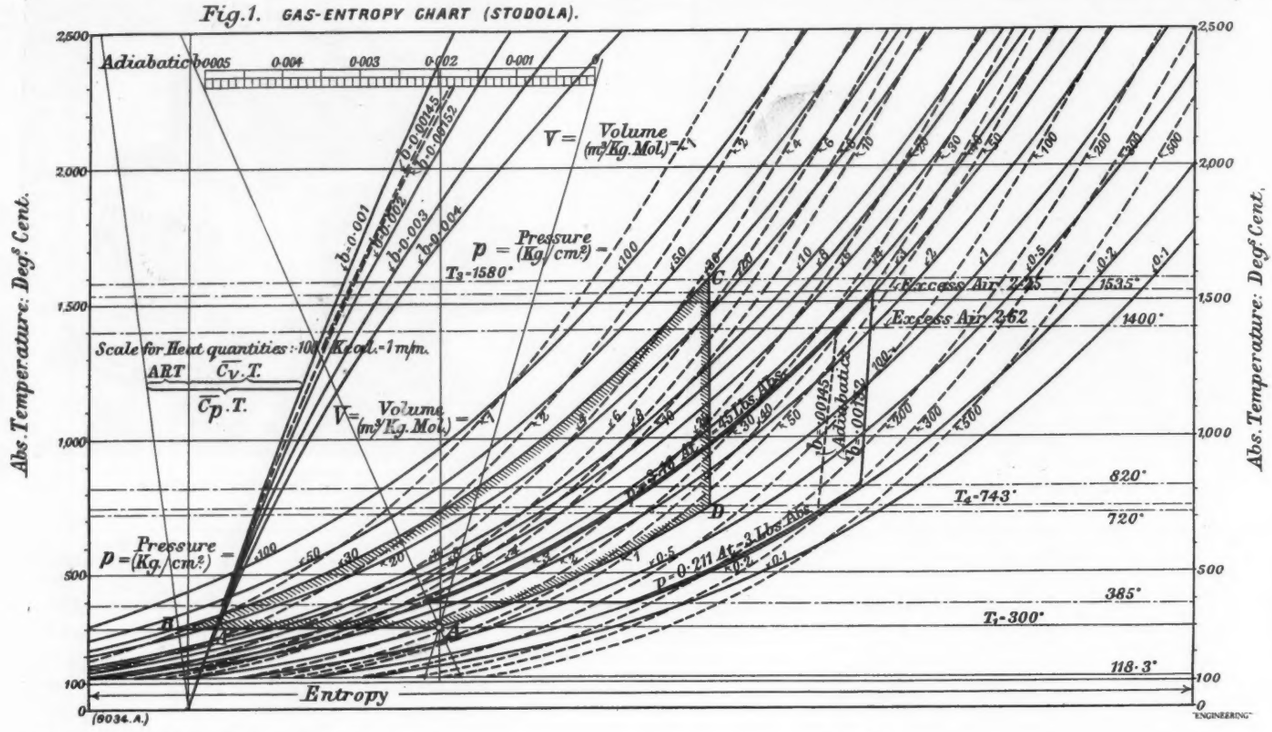
the impulse of another to any appreciable amount without a considerable mixture of the two resulting.

(*b*) *Compression of the Gas Charge by a Water Column.*—This proposal has much to recommend it, and was first successfully employed by Humphrey in his well-known pump. Its further application to the gas-turbine was proposed in a patent of Brown, Boveri. Again, in a somewhat different manner, it is used in the turbine designed by Professor Stauber, which will be dealt with later on.

Another interesting proposal the author quite recently had to comment upon is a gas turbine for locomotives, the main feature of which was the adoption of a partially sub-atmospheric cycle. A centrifugal compressor driven directly by the turbine supplies air to the combustion chamber at 45 lb. absolute, and after combustion at constant pressure the gases expand to 3 lb. absolute, the exhaust gases then being compressed to atmospheric pressure by a centrifugal exhauster on the same shaft. Steam is raised by the cooling of these exhaust gases, admitted in a separate nozzle group of the gas turbine and then condensed in a regenerator.

The thermal aspect of this cycle is rather disappointing when using, as proposed, rotary compressors and exhausters driven by the gas turbine itself. Assuming a compressor efficiency of 67 per cent. and an exhauster efficiency of 65 per cent., and limiting the temperature in the wheel-case of the gas turbine to 840 deg. F., the efficiency of the cycle works out to only about 8 per cent. Should it be found possible however, to use a piston compressor driven by a prime mover of high thermal efficiency, such as a Diesel engine, the efficiency of the cycle would be as high as 26 per cent. The diagram of this cycle is shown in Fig. 1.

Fig. 1. GAS-ENTROPY CHART (STODOLA).



If the efficiency of the turbine is ηt and that of the compressor ηc, the overall efficiency of the cycle is expressed by—

$$\eta \text{ O E R} = \frac{\eta t \left[K - \frac{1}{\eta t \cdot \eta c} \right]}{K - 1} \quad . \quad (1)$$

K is a function of the cycle used, whilst ηt and ηc are dependent on the performance of the compressor and turbine.

The overall efficiency becomes zero if the expression $\frac{1}{\eta t \cdot \eta c}$ is equal to K, so that if, for example, K = 4, and the efficiencies of the turbine and compressor are in each case 50 per cent., no useful work is obtained.

The constant-pressure cycle as applied to the gas turbine, simplifies the construction, and provides favourable conditions for the hydraulic efficiency of the blading, since the latter is subjected to a continuous flow of gases of constant speed. The necessary high compression ratios of this cycle will, however, bar its successful application as long as present-day means of compression are not materially improved.

(3) *Constant-Volume Cycle.*—This cycle was first introduced for piston engines by Lenoir and Otto, and its application to the gas turbine has become the predominant life-work of Holzwarth. The results obtained would seem to show that for the time being, the only successful solution of the gas-turbine problem lies in the application of this pulsatory combustion to a prime mover which is fundamentally more suitable for continuous admission. The main reason for this is the fact that for any given maximum working pressure, and in particular temperature, the constant-volume turbine needs only to operate with much lower compression ratios than the constant-pressure type, and also as far as reliability is concerned, the fact that the periodic nature of this cycle enables one to maintain in the explosion and wheelcase chamber a mean temperature much below the momentary combustion temperature of 2,600 deg. F. to 3,500 deg. F.

From a thermodynamic point of view, the explosion cycle is superior to the constant-pressure cycle.

Proposals and attempts to solve the problem of compression other than by mechanical means are :—

(*a*) *Compression of the Gas Charge by the Kinetic Energy of the Exhaust Gases.*—This idea is contained in a large number of patents. It is very doubtful, however, whether it will be possible to compress a gas by

TABLE I.

Material and Composition.	At Normal Temperature. Ultimate Tons per sq. in.	Yield. Tons per sq. in.	Elongation. Per cent.	At Higher Temperature. Temperature, deg. C.	Ultimate. Tons per sq. in.	Yield. Tons per sq. in.	Elongation. Per cent.
Holzwarth ; for Blades	30	20	27	480	17	12·5	50
High Tensile Steel. C. 0·35 0·37 plus; Chr. 0·60 1·04 0·17 V.; Ni. 3·25 — and; Mn. — 0·74 0·02 P.	65	55 Prop.	—	500	32	8	—
	—	—	—	—	—	—	—
	65	40 Prop.	—	500	42	9 Prop.	—
Monel Metal. Co. 0·30; Ni. 0·65; Mn. 0·015; Iron. 0·02; S. 0·102; Si. 0·014	40	21	36	500	30	15	—
Cast Iron	15	—	—	500	11	—	—
5 per cent. nickel steel	38	32	20	400	29	22	28
25 „ „ „	44	21	40	400	31	16	46
Tungsten Steel .. .. W. 8; Cr. 3·8; C. 1·85; Mn. 0·30; V. —; Si. 0·15 (ordinary)	50	—	21	460	36·4	—	19
	—	—	—	—	—	—	—
18·9 5·5 0·67 1·1 0·29 0·043 (modern)	—	—	—	—	—	—	—
Chronin	48	—	30	1,000	42	—	35
Corronil : 0·70 Ni ; 0·26 Co ; 0·04 Mn. ..	40	20	46	450	41	—	42
Stainless Steel. With 0·09 to 0·23 Carbon	48	39	27	500	29	28	22

THE GAS TURBINE RELATIVE TO OTHER PRIME MOVERS.

Having discussed the principal working cycles employed in the gas turbine, an outline will now be given of the position of this prime mover relative to other prime movers, such as the steam engine, gas engine, and the steam turbine. It is not necessary at this stage to enlarge upon those features of the steam turbine that have secured for it the position which it holds at the present time. With regard to the position of the gas turbine relative to the gas engine, it has to be admitted that the former promises fewer advantages over the piston engine and presents greater difficulties.

Taking for comparison purposes a constant-pressure cycle, and assuming therefrom that the expansion of the working gases is carried down to atmospheric

pressure, it is evident that the theoretical thermodynamical efficiency of this process is the same for an ideal turbine as for a reciprocating machine. In actual practice this statement is not correct, as expansion down to atmospheric pressure cannot well be accomplished with piston engines as the cylinders would be of unwieldy dimensions. The gas turbine, on the other hand, like the steam turbine, is capable of utilising the exhaust end of the indicator diagram. The increase in useful work by the addition of this end may amount to 40 per cent. of the diagram area if the expansion is carried down to the initial pressure, and approximately 80 per cent. if the expansion goes down to the initial temperature.

Although the gas turbine has the capability of dealing with large volumes, it is greatly handicapped in the compression of its charge, whereas in the piston engine both compression and expansion take place in the same cylinder with a high efficiency. In addition to the improvement in mechanical efficiency due to compression and expansion in the same cylinder, the efficiency of the piston compressor is in itself from 10 per cent. to 25 per cent. better than that of a turbo-compressor. The effect of this improvement on the overall efficiency may be seen by substituting in formula (1) a compressor efficiency of, say, 60 per cent., and a figure of 85 per cent. for the piston machine, and taking a turbine efficiency of 60 per cent in both cases.

Then, as

$$\eta t \cdot \frac{K - \frac{1}{\eta t \cdot \eta c}}{K - 1} = \eta \, O \, E \, R$$

$$\eta_1 = 0{\cdot}60 \cdot \left(\frac{4 - \frac{1}{0{\cdot}60 \times 0{\cdot}60}}{3} \right) = 24{\cdot}4 \text{ per cent.}$$

$$\eta_2 = 0{\cdot}60 \cdot \left(\frac{4 - \frac{1}{0{\cdot}60 \times 0{\cdot}85}}{3} \right) = 41{\cdot}0 \text{ per cent.}$$

showing that an increase in compressor efficiency of 40 per cent. improves the overall efficiency by almost 70 per cent.

The gas engine has also an advantage over the gas turbine in the amount of negative work necessary to push the compressed air into the combustion chamber. Another point which for the time being will prevent the efficiency of the gas turbine surpassing that of the piston engine is the fact that the temperatures required are beyond the capabilities of the materials at present available.

In either steam or gas cycle the main losses are represented by the heat contained in the exhaust gases.

In the gas turbine, however, this heat is of a higher grade, and therefore easier to recover. A 60 per cent. recuperation of the exhaust losses in the gas turbine is possible. The prospects of the gas turbine may be severely cut if the modern tendency in steam-turbine practice to use much higher pressures than hitherto employed proves to be commercially successful.

In order to appreciate the present position of the gas turbine, some mention must be made of the difficulties to be encountered in its construction.

The suitability of present-day materials for the construction of the gas turbine can only be decided with a knowledge of the magnitude and nature of the stresses in the different parts of the machine. It is not proposed to enlarge to any great extent upon the combined temperature and centrifugal stresses in shafts, discs, blading, &c., but consideration will be given to the stresses imposed on the most exposed parts of the turbine, namely, the thin inlet and exit edges of the stationary and moving blading. Stodola has shown that if these edges are provided with a reasonable rounding off and are not continuously subjected to the high gas temperature, the resistance to the heat transmission prevents their burning away.

The stresses in the turbine discs are calculated as the super-position of pure centrifugal and pure temperature stress, according to established methods, and to obtain an idea of the stresses to be encountered, the following example can be taken :—

For a wheel of 1,320 mm. mean diameter at 3,000 r.p.m., with a minimum temperature of 300 deg. C. (500 deg. C. gas temperature)—no bore—the following figures work out :—

		Tangential.	Radial.
Temperature stresses kg./cm²	Rim	− 2,810	0
	Centre	713	713
Centrifugal stresses kg./cm.²	Rim	980	157
	Centre	1,500	1,500
Total stress kg./cm²	Rim	− 1,830	157
	Centre	plus 2,213	plus 2,213

Material.—It is the influence of the wheelcase temperature in particular that makes the question of suitable materials the vital point in gas-turbine design. The temperatures in the combustion chamber are not appreciably higher than those to be met with in any internal-combustion engine, and, in particular, those of the Diesel type. Although it may safely be said that, for the stationary parts the question of material is practically solved (many difficulties may still arise from erosion, corrosion and distortion), it would be unjustifiable to pretend the same with regard to blading and disc materials. The gas turbine imposes very stringent conditions, as not only must the peripheral speed of the turbine blading be high, due to the necessarily high gas speeds in single-stage turbines (a multiple-stage turbine being impossible for the time being, on account of maximum allowable temperatures), but the ultimate tensile and yield point of the material is considerably decreased due to the temperatures. To get an idea of the merits of some of the most favourable alloys, relative curves of ultimate tensile strength are plotted in Fig. 2 as a function of temperature, and in Table I are given a few absolute values of their mechanical properties. Bearing in mind the fact that temperatures of 400 deg. C. to 500 deg. C. at the blading are necessary to give a reasonable efficiency, the difficulty of obtaining a suitable material is apparent.

Another important point to be watched is the behaviour of the materials with regard to the action of sulphuric acid, which will be formed if there are traces of water in the exhaust gases. More as a curiosity may be mentioned a recent American report on the successful use of quartz blading.

(B) *Cooling.*—Provision for cooling in gas turbines is unfortunately essential, and the various methods of maintaining a given temperature are :—

(1) Cooling by an excessive amount of combustion air.
(2) Cooling by an injection of water or steam either by mixing or through separate nozzles.
(3) Cooling by separate air, either high-pressure or low pressure, and either through the combustion chambers or through separate nozzles.

Generally speaking, cooling by jacketing or scavenging is inferior to cooling by injection in so far as the energy thus abstracted from the working medium is mostly lost.

(C) *Losses in the Turbine Proper.*—The internal losses may be considered in the same way as in the case of steam turbines, although present-day knowledge does not allow them to be fixed as accurately, this applying in particular to the co-efficients of nozzles and blades, especially in the constant-volume type where there is a rapid variation of the gas speed.

The actual conditions in this type are, however, easier than may be supposed. For example, from an actual working diagram of a Holzwarth turbine (*see* Fig. 3), it will be seen that, with a pre-compression of the air to about 3 atmospheres absolute, the explosion pressure rises to 18 atmospheres, thus producing a maximum gas speed to the blading of about 1,500 metres/second, and 90 per cent. of the available energy is utilised before this maximum velocity falls below 900 metres per second, *i.e.*, if the Curtis wheel blading is designed for a mean gas velocity of 1,242 metres per second with u/c_1 of 0·22, this would mean that the value of u/c_1 would vary between 0·18 and 0·30 with the equivalent variation of the efficiency of 64 to 67 per cent. approximately. A clearance angle of only 5 degrees would be sufficient to prevent the gases hitting the back of the blades during this interval. This latter factor is of fundamental importance, and explains the efficiencies obtained with the constant-volume type. There remains, of course, the heavy loss due to fan action during the relatively long scavenging period (approximately fifteen times the expansion period), when the cooling air has to be accelerated by the turbine wheel itself.

Holzwarth Turbines.—Through the kindness of the inventor, the author is in a position to give a fairly complete account of the Holzwarth turbine, represented diagrammatically in Fig. 4. The main features of the Holzwarth turbine are constant-volume combustion of a slightly pre-compressed mixture, Fig. 5 (lately combined with short constant pressure period, see Fig. 6), in a number of explosion chambers. The whole compression work is done by a rotary compressor driven by an auxiliary steam turbine. This latter utilizes the steam supplied from the regenerators, *i.e.*, the negative compression work is covered by the exhaust gas energy.

The first 50 h.p. machine, built by Körting in 1908, already belongs to history. The second machine designed for an output of 1,000 h.p. in 1910, was erected and tested in the works of Brown, Boveri at Mannheim.

Fig. 2. STRENGTH OF MATERIALS IN FUNCTION OF TEMPERATURE.

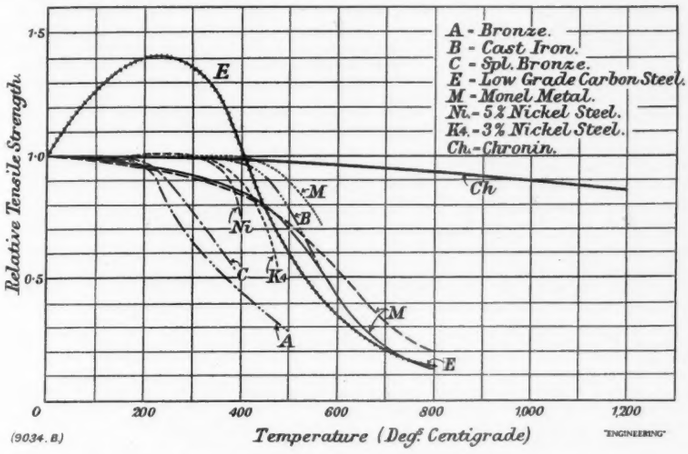


Fig. 3. ACTUAL COMBUSTION INDICATOR DIAGRAM OF HOLZWARTH OIL TURBINE. TAKEN 13-1-25, AT MUHLHEIM ON TEST BED.

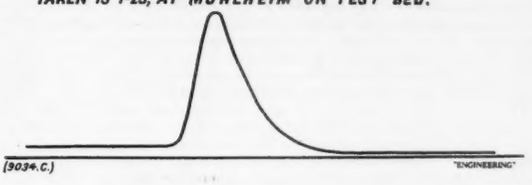
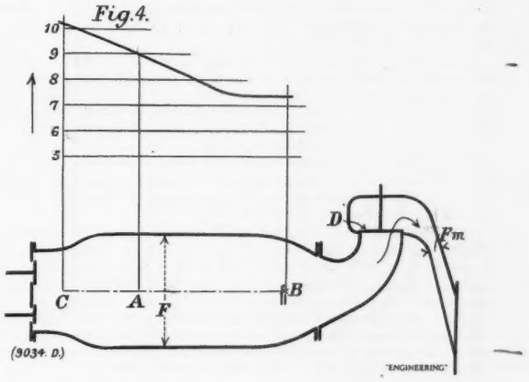


Fig. 4.



This machine was erected again at the Thyssen works, at Mulheim and at the same time considerable alterations were made to the turbine. Subsequent tests in 1921-22 showed a considerable improvement over the Mannheim results, and were convincing enough to induce the Prussian State Railways to place an order with Thyssen for a 1,000 h.p. gas turbine. Test results with a 700 kw. gas turbine and also a 300 kw. oil turbine of May, 1923, are given below. The overall efficiencies of 17·8 per cent. and 16·8 per cent. are remarkable for the outputs. The assumed friction loss of 6 and 9 per cent. is to a great extent guesswork.

It would seem that considerable confidence by those financially interested is placed in these designs, as after four successive machines, a fifth one of 5,000 kw. output at 1,000 r.p.m. has been built and is ready for testing. This turbine consists again of a single Curtis wheel of 10 ft. diameter (weight 12 tons), nozzle height, about 4 in.—second moving blade 6 in. approximately. The pre-compression in the eight combustion chambers is about 50 lb. absolute, at a mean temperature of 200 deg. F. The ignition of the charge by two high-tension plugs raises the pressure to about 250 lb. per square inch at a temperature of almost 3,000 deg. F. The nozzle valve is set so as to open rapidly to its full extent on the action of the first pressure wave. The gases expand through nozzles—in this case of the built-up type—to slightly above atmospheric pressure in the wheel-chamber. Holzwarth claims as one of the main achievements the reduction of the time interval between ignition and completed expansion down to 0·10 to 0·20 of a second (see Fig. 7).

Immediately the expansion is finished, air of slightly above atmospheric pressure is scavenged through the combustion chamber—nozzle valve and wheel-chamber maintaining in the latter a mean temperature of about 800 deg. F. After this period, which lasts about 0·8 of a second, the nozzle valve closes and gas and air valves admit a new charge within 0·5 of a second—a full cycle therefore lasting about 1·5 seconds. (see Fig. 5.) All valves are governed by pressure oil from a central distribution valve.

The blades of the Holzwarth Turbine have the packer, blade and shrouding, stamped in one piece. The material is a soft electrolytic iron with a very low carbon content. The blades possess a grooved root and are inserted in a corresponding groove of the disc head. Earlier troubles due to dilatation which caused the blading to become slack, were overcome by the insertion of a loose wedge piece inside the undercut blade root. By its centrifugal force this wedge piece holds the blading tight to the rim.

It may be added that tests with blading material of greater hardness or alloy steels, have proved to be unsuitable due to alteration of their molecular structure and disintegration of the surface.

Recent Test Results of Holzwarth Turbines. (*May*, 1923.)

(1) 300 kw. oil turbine 3,000 revolutions directly coupled to D. C. generator.

Fuel: Benzol, with a lower calorific value of 8,500 cals./kg.
Specific weight, 0·86 kg. litre.
Total consumption, 161 litre.
Pressure of combustion oil 5·5 atms. effective.
Pressure of scavenging air, 2·6 m. water effective.
Temperature of scavenging air, 32 deg. C.
Air temperature, 18 deg. F.
Air pressure 25·5 m. water effective.

Chamber.	Temp. deg. C.	Indicated Pressures in Atmospheres Absolute.	
		Maximum Pressure at Explosion.	Pressure of Charging.
I	335	15·7	3·5
II	380	16·5	3·3
III	360	17·5	3·4
IV	420	13·0	3·4
V	490	13·0	3·4
VI	470	12·0	3·5

Exhaust temperature, deg. C. ... 560
Revs. of the oil turbine 2,850
Revs. of the governor shaft... ... 40
Amperes 480
Volts 404

This gives the following results :—

Number of explosions per hour $40 \times 6 \times 60 = 14,400$
Fuel per explosion $\frac{161,000}{14,400} = 11{\cdot}2$ c.cm. $= 9{\cdot}6$ gr.
Introduced heat per cycle $0{\cdot}0096 \times 8500 = 81{\cdot}6$ cal.
Electrical output $= 480 \times 404 = 194$ k.w.
Therefore, overall efficiency $= 14{\cdot}2$ per cent.
$$\left(= \frac{860 \times 194}{14,400 \times 0{\cdot}0096 \times 8,500}\right)$$

With a direct-current generator efficiency of 85 per cent., the turbine coupling efficiency works out to 16·8 per cent., and with an estimated disc and windage loss of 6 per cent., the efficiency at the wheel periphery would seem to be about 18 per cent.

(2) Tests with a 700 kw. gas turbine 3,000 revolutions coupled directly to an alternator.

Fuel: Coke gas with a lower calorific heat of 3,476 cal./m³ at 15 deg. C. and 760 m. mercury.
Gas pressure, 3·73 atms. absolute.
Consumption per hour 920 m³.
Gas temperature, 37 deg. C.
Air pressure, 3·62 atms. absolute.
Air temperature, 35 deg. C.
Scavenging air temperature, 27 deg. C.
Scavenging air pressure, 1·24 atms. absolute.
Total air quantity, 17,500 m³/hr. at zero deg. C. and 760 mm. mercury.
Revolutions of the compressor, 5,560.
Revolutions of the gas turbine, 2,980.
Indicated pressure (average of all chambers).
Maximum pressure at explosion, 15·03 atms. absolute.
Maximum pressure of charge 3·54 atms. absolute.
Average temperature of combustion chamber, 440 deg. C.
Average temperature of exhaust gases, 490 deg. C.
Volt, 3,600.
Ampere, 85·5.
Kw., 540.

Fig. 5.

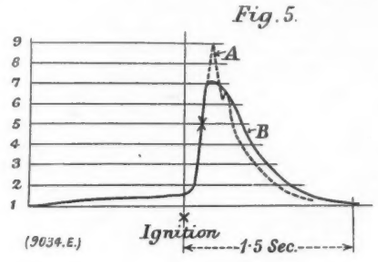


Fig. 6.

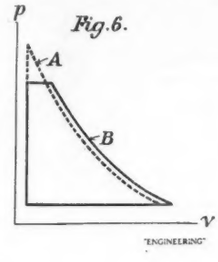
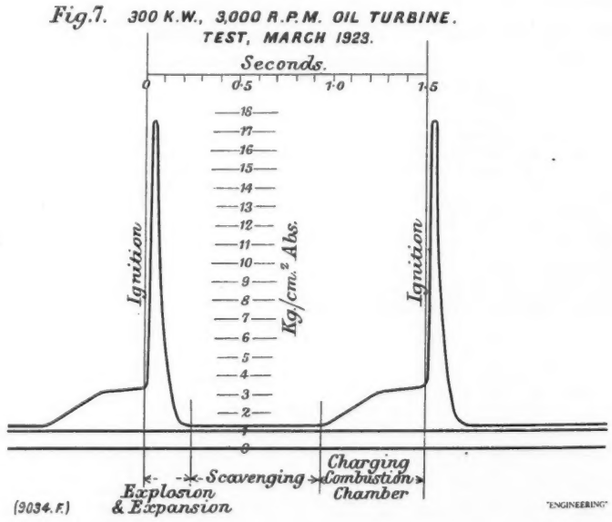


Fig. 7. 300 K.W., 3,000 R.P.M. OIL TURBINE. TEST, MARCH 1923.



This gives the following results :—

Total number of explosions per hour, 20,000.
Total amount of introduced fuel, 3,200,000 cals.
Total heat per cycle, 160 cals.

The electrical output of 540 kw. is equivalent to a thermal efficiency of 14·6 per cent., which, with the assumption of an alternator efficiency of 85 per cent., means 17·2 per cent. turbine coupling efficiency. Allowing for 9 per cent. friction loss, the efficiency at the wheel periphery would seem to be about 19 per cent.

In January of this year, the author again had an opportunity of seeing the 300 kw. oil turbine on full load. Running and governing were perfect. Diagrams taken on the spot showed a most uniform combustion inside the chambers. This machine has been on load about 300 to 400 hours altogether.

The gas turbine has achieved success in the field of supercharging aerial engines for the purpose of maintaining the sea level output at high altitudes.

As far as is known, Rateau was the first to build a supercharging turbo-blower driven by the exhaust gases of the engine, having started tests in 1916. His rotor of tungsten steel had a total weight of 3 kg., and diameter of 18 cm. It ran at 25,000 r.p.m. to 30,000 r.p.m. The turbine developed about 50 h.p. from the exhaust gases of a 300-h.p. engine. The whole arrangement, including all accessories, weighed only about 80 kg. and enabled the output of the main engine at high altitudes to be doubled. Extensive tests with the Rateau principles of drive were also carried out in the United States of America by the G. E. Company. After preliminary tests with a machine designed by Sherbondy, a revised designed by Moss was tested on Pike's Peak, a mountain of 14,000 ft. altitude, in Colorado, and only after it had proved successful was it installed in an aeroplane.

It may give an idea of the value of a supercharger to state that it has been estimated that a 250-h.p. engine provided with a supercharger will deliver at 25,000 ft. altitude as much power as a 1,000-h.p. engine without a supercharger, being, of course, considerably lighter and having less fuel and tankage weight. Without a supercharger, the engine has at great altitudes some benefit of the small back pressure, but the loss due to decreased explosive charge easily outweighs this gain.

In January, 1924, the G. E. Company reported on a considerably improved supercharger running at 33,000 r.p.m. to 41,000 r.p.m., feeding at 35,000 ft. with sea-level pressure. For a total weight of 140 lb. the output is thus increased by 280 h.p. (= 2 h.p. per lb. extra weight).

The author has much pleasure in referring to an English design of gas turbine at present under test, the designers of which are Messrs. Barron, Dale and Packham, and to whom the author is indebted for the following information. Preliminary trials in the early spring of 1924 have resulted in a thermal efficiency of approximately 10 per cent., which is quite an encouraging figure. The turbine is running on a constant volume cycle, the turbine proper being of the simple impulse type, designed for about 200 kw. at 10,600 r.p.m. It drives a direct-current generator through a De Laval reduction gear.

One of the main features of the design is undoubtedly the arrangement of the compressors, which are of the piston type. The negative work in this arrangement, therefore, is done at high efficiency. These piston compressors are driven by a piston engine whose cylinder acts as a combustion chamber, the work of the gases in the piston engine being limited to the negative compression work, the rest of the expansion taking place in the gas turbine proper. Whilst this will undoubtedly enable very favourable efficiencies, it will limit at the same time the unit outputs of the machine, as for a given effective output the compressor has to deliver about half the output of the turbine, *i.e.*, for, say, a 100,000-kw. station, the compressor set would be enormous. The

design is at present arranged for oil fuel; the jacket system of the turbine, together with a regenerator and feed heater, is utilised in a similar way to the Still engine arrangement for the generation of steam which is subsequently admitted to the turbine wheel. The working pressure of the steam is estimated to be 225 lb./sq. in. absolute.

Professor Stauber's turbine is built on the Humphrey cycle, but working on the two-stroke principle. A water column is accelerated by the driving force of gas explosions, and in flowing through the impellers of a water-turbine wheel, renders useful work. The main difficulty of the gas turbine problem, *i.e.*, suitable blading material for withstanding high temperatures, is entirely eliminated. Stauber's turbine is not a gas turbine in the proper sense, but rather a water turbine using the same water over and over again.

In a discussion the author had with Professor Stauber at Berlin in January of this year, the latter was kind enough to give very complete information. The Stauber patents have been bought by a group consisting of the A.E.G., M.A.N., Krupp and Siemens-Schuckert. A machine of 300 brake horse-power to 500 brake horse-power at 500 r.p.m., has been built and has already successfully undergone preliminary trials in which compressed air took the place of the explosive gases. Tests with gas proper are arranged to take place in the immediate future.

The gas is pre-compressed by the swinging water column to about 90 lb. per square inch, and then ignited, reaching a maximum pressure of 200 lb. per square inch.

Professor Stauber estimates that for an output of 10,000 kw. the allowable revolutions per minute would only be about 75, *i.e.*, would require very bulky low-speed generators.

The unsuitability (from a mechanical point of view) of the piston engine for expanding its charge usefully down to atmospheric pressure would seem to point to a combination of piston engine and gas turbine, similar to its use in aeroplane work. This idea has been taken up again and put into effect in a turbine of Brown, Boveri Co., which is described below. It has also for some time been under consideration by the English Electric Company. The design proposed by this company differs from that of Brown, Boveri Co. and others in so far as only the high-speed portion of the exhaust gases proper, and none of the low-speed scavenging air, is utilised. This is made possible by providing extra ports or valves, shaped so as to give proper expansion Again, this utilised portion of the exhaust gases is carried from each engine cylinder in separate pipes to separate guide blade boxes of the gas turbine. Each cylinder, therefore, expands its exhaust gases independently of the others. The advantages of such an arrangement are less variable gas speed to the turbine, *i.e.*, better hydraulic efficiency, and also less danger of setting up any extra back pressure in the engine, as ample area with small friction loss can be provided for the scavenging valves or ports.

It has already been pointed out above that the tail end of the *p.v.* diagram may represent up to 40 per cent. of the indicated output if adiabatic expansion takes place. Calculation shows the possible actual saving, based on a 500 brake horse-power Diesel engine at 200 r.p.m. four cylinders, piston diameter 500 mm., stroke 610 mm., and a consumption of 0·42 lb./b.h.p. may be equivalent to an increase of 8 per cent. in the total output of the engine.

It is interesting to note that 80 per cent. of the total available energy is converted when the pressure has fallen to 2 kg./cm.² abs. or the theoretical gas speed from 774 metres/second to 536 metres/second. If the turbine is designed for, say, 650 metres/second gas speed, the bulk of the energy is thus converted with a speed variation of only ± 15 to 20 per cent. This fact, as previously mentioned, explains the favourable efficiencies realised even with constant volume turbines.

Through the courtesy of Messrs. Brown, Boveri and Co., the author is in a position to give the following information on the firm's Diesel exhaust gas turbine.

This turbine utilises the kinetic energy of the exhaust gases of a Diesel motor without any further pressure converaion. Preliminary tests proved that velocities in the exhaust of the Diesel machine in question up to 280 to 300 metres/second, had no deteriorating influence on either output or efficiency of the Diesel machine. The total exhaust gas quantity, including scavenging air, amounted in this case to 7,200 kg./hour. The available energy, therefore, is about 89 kw., of which the turbine actually gives about 50 to 60 kw.*

The gas turbine is directly coupled to a centrifugal scavenging blower, with an output of 100 to 110 cubic metres per minute, at a pressure of 1·5 atmospheres absolute. The speed of the turbo-blower is 8,200 r.p.m. The required output of the blower is equivalent to 90 to 100 kw. As the gas turbine only supplies 50 to 60 kw., the rest has to be covered by the Diesel motor itself, which renders 500 h.p. at a speed of 400 r.p.m. The turbo-blower is connected through gearing, and hydraulically coupled to the crankshaft of the Diesel engine.*

Field of Application.—A wide field of application for a successful gas turbine is represented by power plants operating on gas from blast furnaces, coke ovens, and gas producers, *i.e.*, in so-called "waste-heat" stations. As the local requirements is usually not a high percentage of the power available, these stations supply their surplus power in co-operation with central power stations. With a few exceptions, in these stations the generators are steam-turbine driven, the steam being raised from gas-fired boilers. It is evident that considerable saving would be obtained by using the gas direct in internal-combustion turbines. Coke-oven gas has for years been successfully used in tests with the 1,000-kw. Holzwarth turbine; in the same turbine producer gas from coke, having a poor heat value similar to blast-furnace gas, proved satisfactory. A successful gas turbine, furthermore, becomes of increasing importance with the trend; faintly marked as yet—to avoid the wasteful direct burning of coal by the adoption of low temperature gasification on a large scale, thus recovering such valuable by-products as oil, tar, gas, &c. In this case, the direct use of the producer gas in internal-combustion turbines would seem to be the most economical procedure. To give an idea of what low temperature gasification means, we may quote (Brownlie in "Power," 1923) that with the exception of purely anthracite coals, one ton of coal of 25 per cent. to 30 per cent. volatility, will give 2·5 to 3 gallons of motor spirit, 18 to 20 gallons of valuable low-temperature oils, 20 lb. sulphate of ammonia, together with 70 per cent. residual low temperature fuel containing 10 per cent. volatile matter. This residual product is a more efficient fuel than raw coal as it burns smokelessly with a higher emission of radiant heat even than coke.

The gas turbine has, furthermore, already established itself in the field of aerial navigation as an exhaust turbine. In time to come, it may possibly replace the piston engine for this purpose entirely, being certainly at a much greater advantage with regard to weight.

In conclusion, the author would like to tender his thanks to those friends who have provided information and assistance, with particular reference to the English Electric Company.

* This would be equivalent to an overall efficiency of the turbine of about 56 to 67½ per cent.

* 50 to 60 kw. represents 13 to 16 per. cent. of the normal output of the Diesel engine.

CONTINUITY TESTING INSTRUMENT FOR EARTH CIRCUITS.

In order to protect the users of electrical machinery from shock, it is necessary for the exposed metallic parts of such apparatus to be efficiently earthed. This is particularly essential in collieries where electrical machinery is often installed and used in confined spaces and in damp situations, so that the risk is greater than is the case with other industrial applications of electricity. Although even in collieries fatal accidents from electric shock are extremely rare, the regulations of the Coal Mines Act call for the testing of all joints of the earth circuits in mines and collieries, to ensure that the circuits are continuous and are capable of carrying any leakage current that may develop from faulty insulation. Such tests, if carried out regularly and carefully, should still further reduce the risk of accident by enabling broken or high-resistance joints to be detected and repaired. It will, of course, be readily understood that the existence of faulty joints in the earthing system may allow the potential of metal parts, thought to be earthed, to rise considerably above the earth potential and thus to constitute an unsuspected source of danger.

To enable the type of tests referred to to be carried out conveniently and expeditiously, Messrs. Evershed and Vignoles, Limited, Acton Lane Works, Chiswick, W.4, have recently designed and placed upon the market a simple portable instrument, known as the Evershed earth-circuit continuity tester, which enables the resistance of a joint, or of other low-resistance conductors, to be measured in a few seconds. The apparatus comprises a moving-coil indicator graduated in fractions of an ohm and mounted on the side of a box containing a secondary cell of the nickel-iron type. Two flexible leads connected to the apparatus are fitted with spikes which are applied to the conductor to be tested, the scale reading of the indicator then giving the resistance of the conductor directly.

The instrument is usually made with two ranges reading to 0·5 ohm and 0·05 ohm, respectively, and, as the scale is divided into 50 practically-equal parts, resistances ranging from 0·001 ohm to 0·5 ohm can be measured. On the lower range, the current flowing from the cell through the conductor under test amounts to about 5 amperes, this comparatively heavy current being necessary in testing the continuity of low-resistance circuits to make sure that the joints have sufficient contact area to carry any leakage current likely to occur. Another point which should be mentioned is that, since the readings would be affected by any variation in the E.M.F. of the cell, a compensating device is provided to adjust for this. The adjustment is carried out before using the instrument by first applying the spikes to a stout copper plate mounted on the top of the accumulator box. The resistance of this plate is negligible, and if the pointer of the indicator is moved to the zero of the scale while the spikes are in contact with the copper plate, the subsequent readings of the resistance of various conductors will be accurate.

When not in use, the spikes fit into clips mounted on the back of the case, and sufficient flexible cord is provided to enable a conductor 6 ft. in length to be tested. Two other models are made for maximum-resistance readings of 0·3 ohm and 1 ohm, respectively, in addition to that with the range previously mentioned.

CATALOGUES.

Electrical Plant.—The General Electric Company, Limited, Magnet House, Kingsway, London, W.C. 2, have sent us three interesting catalogues recently issued and dealing with quick-make and quick-break switches with fuses, switchboards of the interlocked steel-plate type, and the switchgear installed in the Blackpool Power Station and sub-stations.

Reversing Rolling Mill Motors.—We have received a copy of a special catalogue containing a complete illustrated description of the large electric motors made by the English Electric Company, Limited, Queen's House, Kingsway, London, W.C.2., for the Penistone Steel Works of Messrs. Cammell Laird and Co., Limited. The particulars will be of a special interest to engineers concerned with cogging, roughing and finishing mills for very heavy work.

Water-Tube Boilers.—A new catalogue of water-tube boilers has been issued by the Vickers-Spearing Boiler Company, Limited, 20, Kingsway, London, W.C.2. These boilers are made for all usual pressures as well as for working at extremely high pressures. The company supplies complete boiler-house equipment with mechanical stokers and coal and ash conveying plants that are now general in large installations. The catalogue is well illustrated and gives an excellent account of the most recent practice.

Concrete Distributor.—A skip for carrying and distributing freshly mixed concrete is described in a catalogue issued by the Ransome Machinery Company (1920), Limited, 14, Grosvenor-gardens, London, S.W. 1. The "concrete discharging skip," as it is called, is a cylindrical vessel carried by a crane. The skip has a bottom discharge hole and valve, the valve being operated from a shaft at the top by a chain wheel, so that a man can regulate the discharge. The appliance may also be used as a feeder for the tower and chute method of distribution. The skips are made in eight standard sizes with capacities ranging from ¼ cub. yard to 4 cub. yards.

Granaries.—Another of the "occasional letters" from Messrs. Henry Simon, Limited, 20, Mount-street, Manchester, gives particulars of the improvements that are being made by the firm in connection with the storing, milling and conveying of grain. The Cape Town granary, recently completed, is a large building with elevator and a loading-out gantry, extending over the length of two medium-sized ships. This arm carries four loaders, each of 250 tons per hour capacity, so that a ship may be loaded at the rate of 1,000 tons per hour. The intake from railway wagons is at the same rate per hour, and mechanical equipment is provided for cleaning, drying, dust collecting and sack-filling; the storage capacity is 30,000 tons. Particulars and illustrations are also given of plants supplied to the ports of London, Manchester, Cardiff, Newcastle, &c., including types which may be classed as floating, fixed, and travelling. Plants with milling machinery supplied to China, one of 2,500 bags of flour capacity per hour and another of half that capacity, are also referred to.

LAUNCH OF THE S.S. "KONINGIN ELISABETH."—The Koningin Elisabeth, a steel single-screw steamer being constructed to the order of Messrs. L. Dens and Co., of Antwerp, was recently launched by Messrs. Swan, Hunter and Wigham Richardson, Limited, from their Wallsend yard. The vessel is 315 ft. in length, 45 ft. in breadth, and 22 ft. 10 in. in depth to the upper deck, and is the second of four cargo ships building for the regular line of steamers sailing from the Tyne and Antwerp to Italian ports. She is intended to meet the requirements of the highest class of Lloyd's Register, and will carry some 4,600 tons on a normal draught. Water ballast will be accommodated in the double bottom and in the after peak. Four cargo hatches served by nine steam winches and ten steel derricks and a 20-ton lifting gear will be fitted. The propelling machinery will comprise inverted direct-acting triple-expansion engines working on three cranks. The three single-ended boilers being built by the Wallsend Slipway and Engineering Company, Limited, will be placed amidships.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

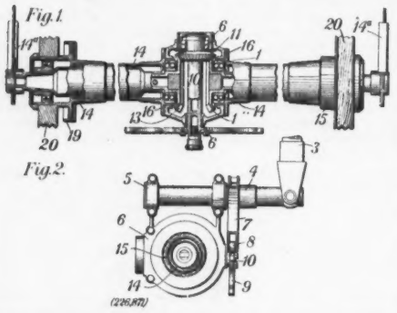
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C.2, at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AERONAUTICS.

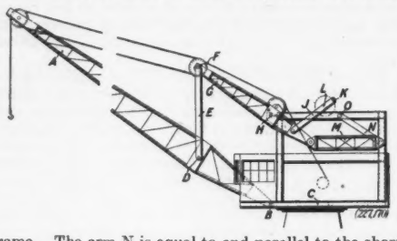
226,871. H. Bolas, Bristol, and G. G. Parnall, Bristol. Control Mechanism. (2 *Figs.*) September 27, 1923.—The invention relates to that type of aircraft wherein lateral control is governed by means of ailerons and the camber of the main planes is varied by means of the alteration in the angle of attack of hinged sections of the main planes, termed "flaps," which may be additional to or identified with the ailerons. The control stick 3 is pivotally mounted on a sleeve 4 mounted in brackets 5 supported from a central housing 6. The sleeve 4 has secured thereto a two-armed lever 7, rollers 8 in the ends of which traverse the shaped upper surface of a rocking plate 9 and effect a rocking movement thereof in accordance with the motion of the control stick. This plate 9 is secured to a spindle 10 mounted in bearings in the housing 6, the spindle 10 carrying at its inner end a bevel pinion 11 adapted to mesh with bevel pinions 12 and 13 mounted on the inner ends respectively of two tubular rods 14. These rods 14 at their outer ends have attached thereto cranks 14*a* to which are attached the ordinary aileron control cables or rods. The rods 14 are concentrically surrounded by tubular housings 15, the housings 15 being secured at their inner ends to rings 16 secured to the central housing 6. At their outer ends the housings 15 are mounted on the outer race of a ball bearing, the inner race of which positions and supports the outer ends of



the rods 14. Ball races are also disposed between the periphery of the inner ends of the rods 14 and the inner periphery of the rings 16. Mounted on the outer end of one of the tubular housings 15 is a crank 19, which is connected with a lever located in the pilot's cockpit for varying the camber of the planes by means of hinged flaps in a well-known manner. The operation of the mechanism is as follows:—Lateral movement of the control stick 3 through the cam plate 9, spindle 10 and the bevel gears 11, 12 and 13 effects the rotation of the rods 14 in oppositite directions thereby moving one aileron up and the other down, thus admitting of lateral control in the ordinary manner. When it is desired to vary the camber of the wings, a lever connected to the crank 19 is moved and this effects a partial rotation of the tubular housings 15 and the central housing 6 within the bearings in the members 20. This motion of the central housing 6 with the consequent motion of the spindle 10 effects, by reason of the intermeshing of the gears 11, 12 and 13, a partial rotation of the rods 14. This rotation of the rods 14 is effected in the same direction, and hence the combined ailerons and camber flaps are moved together in the same direction on each wing thereby altering the camber of the wing. Rocking of the cam plate 9 subsequent to this operation admits of the control of the ailerons in the manner hereinbefore described. (*Sealed.*)

LIFTING AND HAULING APPLIANCES.

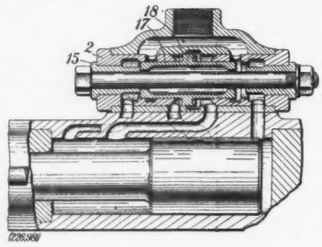
227,170. T. Souness, Finchley, London. Luffing Cranes. (1 *Fig.*) October 6, 1923.—The invention has for its object to provide improved mechanism whereby the jib is luffed in and out directly (not by means of ropes) in such manner that on reaching either of its extreme positions its movement is automatically reversed if the power be left on. A is the jib, which is fulcrummed at B to the frame C. Pivoted to the jib at D is one end of a link E, the other end of which is pivoted at F to the long arm of a lever G, which is pivoted to the frame at a point H, which is vertically above the fulcrum B, the lengths BD, DF, FH being all equal. The short arm of the lever G is connected by a rod J to a crank-pin K, which can revolve about an axis L, so that the jib A can be luffed in or out by the movements of the crank-pin. If the power be left on so that the crank-pin K continues to rotate, the jib will simply be luffed in and out and no harm will be done. The short arm of the lever G is connected by a link M to an arm N pivoted at O to the



frame. The arm N is equal to and parallel to the short arm of the lever G so that the link M moves horizontally. From the pin which connects the link M to the arm is suspended a counterweight, so that the jib is balanced in all positions. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

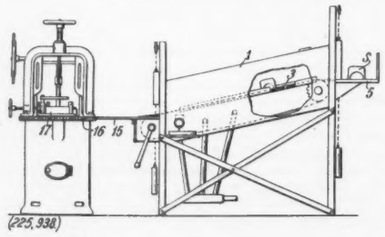
226,981. J. L. Holman, Camborne, and A. T. Holman, Camborne. Fluid-Operated Reciprocating Machine Tools. (2 *Figs.*) January 11, 1924.—The invention relates to fluid-operated machine tools such, for example, as rock drills. According to the invention, a valve and valve chest is characterised in that, not only are the valve bushings 2 each formed or combined with an inwardly extending stop 15 to engage



with an end face of the valve 17 at the limit of its travel towards that bushing so as to afford a stop or beat for the valve, but, in addition, a central or intermediate portion 18 of the valve is made of larger external diameter than that of the two ends thereof and projects and travels between the inner end faces of the bushings in sliding contact with the inner surface of the valve chest and to control directly an exhaust port opening in that surface. (*Sealed.*)

MINING, METALLURGY AND METAL WORKING.

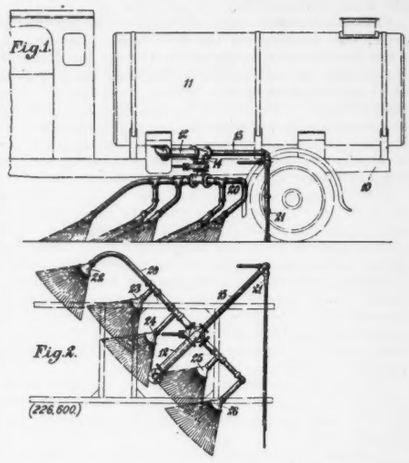
225,938. I. Hall, London. Die Casting. (7 *Figs.*) September 12, 1923.—The invention relates to die casting. The oven 1 contains a chain conveyor 3. A shell S to be lined is placed upon the platform 5 and slid forward on the conveyor 3. The shell S is discharged from



the oven upon a table 15. The prepared shell is then passed on to the table 16 of the die casting machine, where it is placed over the core 17. Molten white metal is then forced into the cavity present between the core 17 andthe shell S, whereupon the lined shell may be immediately removed. (*Sealed.*)

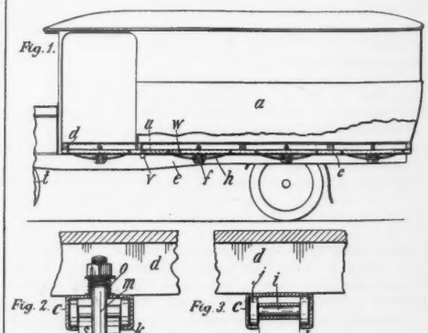
MOTOR ROAD VEHICLES.

226,600. C. E. Esse, Barnes, London, and The Associated Equipment Company, Limited, Westminster, London. Road-Washing Vehicles. (5 *Figs.*) November 22, 1923.—The primary feature of the invention consists of a road-washing vehicle which traverses the surface to be washed and carries devices for delivering upon such surface, preferably under pressure, two streams of fluid, which reach the said surface simultaneously but at different angles and follow the one after the other in such manner that each section of the surface traversed is washed by a leading stream reaching it from one direction and by a following stream reaching it from a different direction. The chassis 10 supports a tank 11 from the underside of which leads a main supply pipe 12 connected to two branches 14 and 15. The branches 14, 15 are controlled by valves operatively connected to some point adjacent the operator's seat. The branch pipe 14 supplies a pipe 20, which lies substantially horizontal, but is obliquely arranged. The branch pipe 15 extends to the rear of the oblique pipe 20 and terminates in a nozzle 21, which is directed downwards and from the off to the near side of the vehicle in a vertical plane substantially at right angles to the fore and aft centre line of the vehicle. The pipe 20 supplies nozzles 22, 23, 24, 25 and 26, which are so arranged that they lie at an angle of 45 deg. to the direction of traverse



of the vehicle and that the jets from them strike the ground at an angle of approximately 30 deg. The nozzles 23, 25 are arranged nearer to the oblique pipe 20, as viewed in plan, than are the nozzles 22, 24 and 26. Moreover, the nozzles 23, 25 are situated nearer to the nozzles 24, 26 respectively than they are to the nozzles 22, 24 respectively. (*Sealed.*)

226,575. J. M. Strachan, North Acton, London. Motor Vehicle Body Suspension. (11 *Figs.*) July 19, 1923.—The invention relates to motor vehicles of the kind in which the body is yieldingly supported by springs carried by the chassis, which is also supported by springs between it and the road wheels. According to the invention, the chassis is provided with a number of semi-elliptical springs on both sides that are supported by brackets secured to the chassis. The vehicle body *a* is supported upon a subsidiary frame comprising longitudinal side-members *c* tied together by transverse members, which may be the cross-beams *d* of the body. The chassis *e* is provided with road wheels *t*, sprung in the usual way, and has brackets *f* bolted to it to support semi-elliptical springs *h*. The extremities of the upper leaf of these springs are bent around pins *i*, on whose ends are mounted rollers *j* adapted to roll in guides formed in the longitudinal members *c* of the subsidiary frame. The



longitudinal members *c* are of inverted U-section with inwardly projecting flanges *k* at the lower ends of the legs of the U, which form lateral channels within which the rollers *j* roll. The leaves *g* are clamped to their respective brackets *f* between each and a plate *l* having an upward extending pin *m*, by U-shaped clamping bolts *n*. The upward extending pin *m* is threaded and passes through a hole in the longitudinal members *c*, above which it is surrounded by a helical spring *o* situated between washers and there retained by a nut which limits the upward movement of the car body, which is cushioned by the spring *o*. The pin *m* is surrounded at its base by a buffer ring *r*, having a plate *s* above it, which together form a cushioning stop to limit the compression of the springs *h*. Connecting links *u* are pivoted to brackets *v* on each side of the chassis and to suitable pivots *w* extending laterally from the longitudinal members *c* of the subsidiary frame in order to prevent undue longitudinal movement. (*Sealed.*)